THE OHIO JOURNAL OF SCIENCE

VOL. XXV MAY, 1925 No. 3

SOME CONSIDERATIONS OF PROTOPLASM.

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One of the most fundamental problems in biological science is that which concerns protoplasm. Yet there is great diversity of opinion among biologists regarding what constitutes protoplasm and some doubt whether the term protoplasm is really worth retaining. In the present state of knowledge, protoplasm can not be defined in any terms of physical structure which will be accepted, without qualification, by a majority of botanists, and can only be defined somewhat more satisfactorily in terms of colloidal chemistry. Again, though chemical definition is somewhat more certain than physical, this alone is far from satisfactory to those who think of cell contents in terms of microscopic structure.

It is sometimes stated by certain biologists that protoplasm is essentially alike in all organism. This may be true in the rough if we define in purely chemical terms; or if we content ourselves with the statement that protoplasm is the living substance of the cell, knowing not how much of the cell is alive, and, therefore, protoplasm. Turning to those very lowly organized plants, the bacteria, most of us will agree that the whole cell content, inclusive or exclusive of the vacuoles, composes the protoplasm. For higher fungi and for animals the situation is about the same, except that definite nuclei here replace the nuclear granules commonly supposed to exist in bacteria. Turning attention to higher green plants, we find that the cells are much more complex with respect to visible contents. This is especially true of all the cells of lower algae and of those cells of higher bryophytes, pteridophytes, and spermatophytes in which photosynthesis is carried on.

Regarding these chlorophyllous, photosynthesizing cells of green plants, every possible position has been taken respecting the portion of visible cell contents which may constitute the protoplasm.

Knowing well that the problem was not a very fundamental one, the writer, like other teachers and investigators, has had to puzzle about what visible and therefore obstrusive portions of the protoplast or whole cell content should be regarded as protoplasm. Finally, in November, 1923 he addressed a questionnaire to about sixty teachers in colleges and universities, merely asking which of these elements each one would regard parts of the protoplasm. More than forty replies resulted from the letters; and the views expressed were readily arranged in four general catagories for presentation at the meeting of the Botanical Society of America at Cincinnati, in December, 1923. Following this, those who had not replied and a few others were circularized, asking which of the four catagories which resulted from the first letters each one would favor. The result of the two efforts was more than sixty replies. The circular letters stated that the writer would feel free to quote from the replies; and quotations from some of the most valuable discussions will form an important portion of this paper. The statistical results might have been more valuable if a larger number of botanists had been consulted. Yet the selection of persons whom to address was carefully made; and the writer believes that what follows will be found valuable, especially to those who have had little time for the formulation of a basis for thinking and teaching regarding protoplasm.

Seven of the botanists who replied adhered to one position which grew out of the questionnaire, namely that protoplasm consists of cytoplasm and nucleoplasm, the latter more commonly in the form of a definite nucleus. The adherents to this belief are H. C. Cowles, R. P. Hibbard, E. C. Jeffrey, O. E. Jennings, C. B. Lipman, G. B. Rigg, and A. R. Sweetser. After a general discussion, Hibbard says "In many cases I would agree with class two, but there are some masses of nucleated protoplasm that do not contain plastids. So to cover all cases I would take my stand with class one." In explanation it should be stated that class two as presented at Cincinnati is the next following. Jeffrey says in part "I suppose, strictly speaking, the term protoplasm should be limited to the nitro-

genous, undifferentiated contents of cells. If one goes beyond that, I do not see how it is possible to avoid everything, including the wall." The present writer began many years ago with the belief held by these seven men, but turned recently to the view that the whole cell content should be regarded as protoplasm. However, the wall is like certain cell inclusions with respect to origin, and he sees plainly the force of Jeffrey's logic. The following from Jennings is peculiar: "Possibly plastids have as their original basis certain differentiated portions of the protoplasm, just as I would consider the nucleus a highly differentiated portion of the cytoplasm." Of course the relation of plastids and nuclei to protoplasm and cytoplasm depends in part on definition of these last two components of protoplasts, and the writer is content for the present to quote Jennings without further comment.

After stating his view, Cowles says "I have talked with Chamberlain, who gives our Cytology courses, and he also treats the subject as I have." It appears, however, that Chamberlain believes quite differently. He says "For convenience of reference, I use the terms cytoplasm and nucleus; but I do not use the term protoplasm to cover the two taken together. Whenever we use the term protoplasm at all, we use it loosely as a synonym for cytoplasm." Shull's statement, quoted in full later in this paper, differs from both Cowles and Chamberlain. There are advantages in likeness of presentation within a department; but of course independence in thinking is preferable. Coulter referred the writer to Shull as spokesman for the department; but it is stimulating to find that the department cannot be spoken for by one man.

According to the best analysis that the writer can make, thirty-eight botanists addressed took essentially a second position which grew out of the questionnaire, namely that protoplasm consists of cytoplasm, nucleoplasm and plastids. These botanists are G. M. Armstrong, H. W. Barre, H. H. Bartlett, A. R. Bechtel, D. H. Campbell, A. H. Chivers, H. S. Conard, M. T. Cook, O. F. Curtis, B. M. Davis, A. W. Evans, J. H. Faull, M. C. Ferguson, W. F. Ganong, W. A. Gardner, F. O. Grover, J. W. Harshberger, D. S. Johnson, F. D. Kern, J. E. Kirkwood, B. E. Livingston, J. N. Martin, H. F. A. Meier, F. T. McFarland, A. Nelson, S. P. Nichols, L. H. Pammel, R. J. Pool, J. H. Schaffner, W. A. Setchell, L. W. Sharp, C. A.

Shull, A. G. Stokey, E. N. Transeau, W. Trelease, A. E. Waller, K. M. Wiegand, and R. B. Wylie. Davis qualified by calling attention to the fact that plastids are not present in parasitic and saprophytic plants. Faull stated that "pyrenoids are looked upon as specialized areas within the plastids and constitute a part of the plastid substance." This statement is related to the addition of pyrenoids by one or two other botanists. Johnson added that blepharoplasts are sometimes to be included. Martin would add pyrenoids and chondriosomes. Sharp referred me to his text on Cytology, and it would seem from statements, pages 133 to 135, that he belongs with this group. Wylie would add to cytoplasm, nucleoplasm, and plastids the plasma membrane. Bartlett wrote at considerable length, and want of space compels doing injustice to his valuable statement by passing it with record of the fact that he regards water and chlorophyll parts of protoplasm.

Campbell's statement is much shorter, and it represents the general belief of these 38 botanists fairly well. His statement runs thus: "In discussing protoplasm before my classes, I have considered the whole living contents of the cell, cytoplasm, nucleus, and plastids as constituting the protoplasm. I should not include vacuoles, starch grains, protein granules, or cell wall under this head; and I have tried to make clear to students that we can not look upon protoplasm as a definite chemical substance, but that it is a mixture of a very great number of complex substances, and is in a state of constant change, due to the activities within. Hence no chemical analysis can represent the true composition of living protoplasm as it must also include various inclusions of the protoplast which are not constituents of the living protoplasm."

Livingston's 800-word statement deserves quoting as a whole, but we can take space only for the following, which contains an interesting thrust and several very illuminating comparisons. He says in part "I don't care what protoplasm is so long as we know how it is built and how it operates. The problem is somewhat like asking for a definition of soil or air. If I take the water out of the soil or air, I still have soil or air. If I take the nitrogen out of air, it is still air, I suppose, but perhaps it isn't if I take the oxygen out. Take the dissolved salts out of soil, or take the dissolved gases out of soil, and it is still soil. But take the solid grains out, and we don't consider

it soil any more, even though the undissolved gases are present, as in sea foam. It seems foolish to try to define air, or soil, or protoplasm, or mince-meat, or plum-pudding, or chocolate fudge, or house-paint. When we attempt to define them we discover that there are many kinds of each, and that all of the constituents of any one mixture may be left out and replaced by different materials, without requiring the use of another general term. If a whole apple were found in the middle of the plum-pudding, we'd not call it a part of the pudding any more than if it were the baby's rubber doll that had been included by mistake. But if we took all of the dead grapes out of the plum-pudding, it wouldn't be a plum-pudding any more! Apparently the distinction is based largely on size. Small pieces of apple are part of mince-meat, but larger pieces (fix your own limits of size) would be considered foreign bodies surrounded by mince-meat." It is from other portions of his discussion that it was concluded that Livingston believes in a general way that protoplasm consists of cytoplasm, nucleoplasm, and plastids; and some violence has been done in taking the above quotation out of its setting because of its intrinsic value.

Shull has expressed himself as follows: "For some time I have used the criterion of actively living substance for living protoplasm; and for dead protoplasm, such material as had been once actively living. I have never considered the vacuoles, starch grains or protein granules, or oil droplets as real parts of the protoplasm. They are parts of the cell when one is classifying the structures found in the cell unit of structure; but I would consider the starch grains and other food inclusions as mere storage products, stored temporarily and conveniently in the region of living substance for more or less immediate use. But I do not see how we could consider them parts of the living substance until they had been assimilated and synthesized into metastable protoplasm molecules of some kind. On the other hand there is reason for considering chloroplasts and leucoplasts as protoplasmic bodies, likewise mitochondria. Certainly a part of their substance is actively living, whether the chlorophyll is or not. From this point of view the wall would hardly be called living matter. It is no more alive than the starch grain, and like the starch grain may be considered the condensed product of enzymic action on the soluble carbohy-

drates. It seems to me highly probable that the pyrenoids, like chloroplasts are real protoplasmic bodies. It now becomes necessary to state what is meant by Being alive as used above. By that I mean possessing the power to carry on the peculiar synthetic and destructive chemical processes which involve utilization and release of chemical energy. If one includes all the structures that you mention, and adds the cell walls, there is just as much reason for adding crystals of calcium oxalate and other crystalline inclusions, according to which the whole body becomes protoplasm and the term protoplasm absolutely devoid of meaning." This statement was referred to in connection with the statements of Cowles and Chamberlain. In a number of important respects, it differs from all other statements, and, therefore, it is of special interest.

After stating her position, Miss Stokey says "My inclusions and exclusions are based in part on their origin and in part on their persistence or stability. I include in protoplasm the parts of the cell which arise from the division of similar parts and not those which arise *de novo*. I do not include those parts which maintain their identity after the death of the cell or which do not have the unstable structure which is characteristic of cytoplasm and the nucleus,—structures which die." Nothing similar to this very suggestive statement has occurred elsewhere in the correspondence.

Five botanists who replied took a third position which was an outgrowth of the questionnaire, namely that the unit of protoplasm is the protoplast or whole cell content. These botanists are C. E. Allen, C. O. Appleman, T. C. Frye, J. B. Overton, and R. Stratton. Allen says "Both in print and in speech there is a good deal of confusion among biologists as to just what we mean by protoplasm and cytoplasm. We have thrashed over the question here at various times, and have always come back to the definition which—I think, was originally due to Strasburger—namely, that protoplasm includes everything within the wall, and that cytoplasm includes all the protoplasm except the nucleus. In case there is no wall or equivalent non-living structure, the whole substance of the cell is protoplasm. These definitions are at least workable. When we come to the question of just what parts of the protoplasm are living and what are non-living, we find ourselves involved in endless discussion. To attempt, as some

do, to define protoplasm as living matter makes the definition depend in turn upon just what is meant by living matter—a conception which no one at present can define." This strong statement may well stand for the view that the whole protoplast constitutes the protoplasm. In connection with it, the logic of Jeffrey and the statement of Shull about what it means to be alive should be recalled.

Appleman is in general accord with Allen, but the following must be quoted: "The protoplasm of the cell may be conceived to consist of a polyphase colloidal system with systems within systems. The nucleus would be a system within a system. Smaller systems may exist within the nucleus. Each system is bounded by a surface membrane which is an integral part of the system and merely represents local concentration of certain constituents of the system. In the development of this conception I include in protoplasm not only the biocolloids but all other substances dispersed in the dispersion medium, as salts, sugar, starch grains, etc." It seems possible from Appleman's statement regarding membranes that he may regard the cell-wall part of the protoplasm.

C. C. Curtis and R. B. Harvey follow the fourth and last position arising from the questionnaire, namely that the whole cell, including the wall, constitutes the unit of protoplasm. Also it is not certain that Appleman should not be placed here rather than with the last group above. O. F. Curtis was placed in the second group,—but he has strong leanings toward the present one. First he says "Ordinarily I would consider statement number 2, 'Plant protoplasm consists of cytoplasm and nucleus, plus plastids,' perhaps the easiest working basis for distinguishing protoplasm from other portions of the cell." Then, after a statement somewhat similar to Allen's, he says "For this reason I often point out that your statement number 4, 'Plant protoplasm consists of the whole cell content plus the cell wall,' is in many respects less disturbing, for there is then no danger of leaving out any part that may be of great importance in the working of the cell." The two quotations from the writer are from the catagories used at Cincinnati. R. A. Harper referred the writer to his discussion of "The structure of protoplasm" in his presidential address for the Botanical Society of America, at the Pittsburgh meeting, December, 1917. The writer understands that this

paper favors the view of protoplasm considered in this paragraph; but there was no thought of attempting to define protoplasm, except for the purpose of the discussion at hand, and one might well object to being held for a position taken for a special purpose several years ago.

Finally, we have reached a group of botanists whose statements cannot be classified according to the criteria used in this paper. R. C. Benedict, E. A. Bessey, B. M. Duggar, F. E. Lloyd, W. J. V. Osterhout, G. J. Peirce, and H. E. Pulling constitute this group. Benedict regards the idea that cytoplasm and nucleoplasm constitute protoplasm "standard and teachable in elementary courses." He thinks the definition which would add plastids "not worth consideration as distinct from others," presumably because he regards plastids as part of the cytoplasm. He believes also that the protoplast, or this plus the wall, may be regarded the unit of protoplasm. He says these dispositions are "both defensible but require more than elementary courses to develop and be understood." Bessey says in part that he agrees with Sharp on some points and differs on others. Part of his statement runs thus: "I think we must look upon the protoplasm of the cell, not as a series of small biophores floating in a non-living medium, but as a polyphase colloidal system whose chemical and physical inter-actions are the phenomena which we interpret as life phenomena. It would be idle, then, to say that there is only one particular chemical substance in the cell that is alive and that the rest is not alive. It is the sum total of the protein and related substances that contribute to the life phenomena." The statement is no less valuable, simply because the present writer does not attempt to place it in his scheme. Apropos of placing Sharp and not placing Bessey, who agrees in many respects, it may be added that Schaffner, Sharp, Livingston, and one or two others might perhaps have been placed in this galaxy of botanists who seem to be unclassifiable for our present purpose.

Duggar, it appears to the writer, has made a contribution which no doubt reflects the feelings of some others with respect to being classified, and which may be otherwise more valuable because it does not fit into our scheme. He says "It is extremely difficult and often unfortunate, it seems to me, to

commit one's self to categorical distinctions. To the enumeration of four categories designated in your letter the criticism might be made that no one of them would properly define protoplasm at all times; for example, at an early stage of growth a plastid might be protoplasmic, while later, though recognized morphologically as a plastid, it might be made up largely if not entirely of fat or gum-like materials. Since the protoplasm frequently penetrates the cell wall, the cell wall must often be an intimate part of the whole unit, but it may be that this is not always so. In the same way one can work out a close relationship between almost any product of the cell and the cytoplasm or nucleoplasm, and it would be difficult to say just when sufficient 'control' of a product ceased, or when it became less subject to the coordinating properties of the protoplasmic matrix. In short I could not accept any of your four categories in toto."

Peirce replied in terms of colloidal chemistry. His statement was prepared carefully for a forthcoming text book, and we quote it in full as follows: "Protoplasm is a colloidal mass in which water and a great variety of substances exist together, the water being the solvent of many of these substances, the medium of colloidal suspension, and of emulsion of others, thus being external to some and enclosed in others, and therefore held with a firmness which may be overcome only with the application of great force. The various colloidal systems forming the colloidal mass called protoplasm may have only water in common; for they may consist of water and gelatinous substances, sols or gels, the water being external to and suspending the sol or gel and escaping with ease, or enclosed within the gel and removable only on the application of many atmospheres of pressure; of water and proteins, complex compounds with large molecules, which are condensation products of amino-acids, behaving like acids toward strong bases and like bases toward strong acids, since they contain groups, carboxyl and NH^2, giving them these respective properties; and of other substances. Thus we have, in its static condition, an enormously complex mechanical, physical-chemical, physiological system; but since it does not exist in a perfectly static condition, the complexity of the system is added to directly in proportion to the activity of the protoplasm, and

its activity is entirely dependent upon the relative proportions of the actions and reactions of the members, inclusions, and products of its component colloidal systems."

In the letter which accompanied this statement, Peirce says "I am somewhat amused to think of the contrast between this statement and some which you will no doubt receive from others of the sixty to whom you have sent this letter. I can imagine, for example, my colleague, Dr. Campbell, scarcely using a single one of the words which I have employed, and yet his idea of protoplasm is as clear and definite as mine, perhaps more so." The reader is here referred to Campbell's statement in a previous paragraph of this paper. It seems more understandable for the beginner, though no doubt more open to criticism than Peirce's statement.

Pulling has likewise failed to see any great value in the classification used in this paper, but has made a keen analysis of the situation regarding protoplasm. His statement runs thus: "I do not see how it is possible for anyone to subscribe to any of the four statements, because the terms are not the same. Protoplasm is, I think, generally intended as the name of a hypothetical living substance. By hypothetical I merely mean that no substance has ever been indentified as living, but the conviction remains that it will be some day found. When found it must be indentified by how it behaves. Nucleus cytoplasm, plastid, cell wall are all topographical terms. They refer to parts of the cell. How then can one say that protoplasm consists of these things? Of course it may be so. If what the microscopist sees when he looks at cytoplasm is living matter, then it is protoplasm. But all he knows is that what he sees is a portion of the cell in which (by definition of the term protoplasm) there is protoplasm while this portion of the cell exhibits those characteristics that we consider are indicative of life. I do not think this is splitting hairs. A crystal within the cytoplasm is termed an inclusion, so is a fat droplet. What evidence is there that all the visible colloidal material is not also an inclusion? The protoplasm may be an infinitely diluted constituent. I think that we need not hesitate to say that there is protoplasm in nuclei, cytoplasm, plastids, and in all cell walls during part of their life, or existence as part of a living cell, using the term protoplasm as defined above. I don't see that the problem of protoplasm or of life,

or of the functions or characteristics of cell parts is the clearer for such a statement, but I make it in the hope that it will be of service to you." Pulling's statement seems unanswerable, and if, by any chance, protoplasm is the attenuated substance which he thinks it may be, the beliefs of all who have contributed to this paper are wrong. Whatever may be the nature of protoplasm, his arguments, like those of Duggar, strike a hard blow at the method of classification used in this paper and many other current treatments of protoplasm.

Osterhaut states that in a broad sense he used the term protoplasm to include the whole cell content and in a narrower sense he excludes vacuoles, crystals, oil drops, starch grains, etc. He seems at one time to belong to our second group and at another to our third.

Because of lack of space, there are some answers not quoted, which contain matter that would add considerably to the merits of this paper. Among these are the replies of Bartlett, Cook, Harvey, Kern, Lloyd, Pammel, Pool, and Shaffner. Some of the points made in these replies will appear in the summaries below.

Summarizing first on the four points which are the main outgrowth of the questionnaire, seven botanists replied to the effect that protoplasm consists essentially of cytoplasm and nucleoplasm. Thirty-eight would add to this plastids, and some of them one or two other portions of the protoplast. Five would make protoplasm synonymous with the protoplast, or whole cell content. Two or three would add to this the cell wall. Seven sent in replies which cannot be classified according to our scheme. Two heads of departments, J. M. Coulter and E. M. Freeman, referred the writer to other men in their departments.

On other matters partly suggested in the questionnaire, thirteen have referred to protoplasm as the living matter of the cell, and two have stated that it is not possible to distinguish between living and non-living. Ten have emphasized the fact that protoplasm is a polyphase colloidal substance. Six regard vacuoles, with their cell sap, part of the protoplasm, and thirteen have stated that vacuoles should be excluded. Five regard pyrenoids a part of the protoplasm, and three would exclude them. One would make chlorophyll a part of the protoplasm, and five would exclude it. Blepharoplasts,

chondriosomes, and centrosomes are each mentioned by one or two as parts of the protoplasm. Three mention water as a portion of protoplasm, and an equal number would exclude it. Two would include that portion of water which is in intimate relation with other portions of protoplasm and exclude the rest. Protoplasm and cytoplasm are regarded as synonyms by two botanists. These data give some idea of the unsettled condition of opinion on some points not otherwise summarized herein.

An occasional reply mentions food material, mucilage, gums, inulin, sugars, fats, oils, resins, tannin, aleurone, enzymes, acids, crystals, cystoliths, and other miscellaneous substances as not belonging to protoplasm. Of course those who regard the protoplast or the whole cell the protoplasmic unit would include whatever of these might be present in any cell as part of the protoplasm of that cell. However, these substances were uniformly mentioned by persons who take a more limited view of the composition of protoplasm.

Some interesting comments were made respecting the cell wall. Three persons stated that the wall contains protoplasm, and two of these regard the wall partly alive. Martin says "In the more advanced classes, I teach that in some cases at least a portion of the wall is modified cytoplasm still living. There are a number of cases where this is certainly true. I have recently been working on the papillae of the stigma of the Easter Lily, finding that the inner one-half or more of the wall is modified cytoplasm still maintaining life sufficient to modify itself into a mucilaginous substance. Strands of wall and cytoplasm grade into each other."

We have classified as best we could the opinions of a considerable number of botanists regarding the nature of protoplasm, viewed from the standpoint of visible cell contents. We have also considered some replies which do not fit into the system of classification used herein. For the writer, the results would seem worth while, even if he got no more from them than the reactions of many botanists on a problem so important, so difficult, and so little understood. Yet it seems scarcely possible that any botanist, except possibly those who have spent most time on the problem, could study carefully what has been presented without having his ideas regarding

protoplasm modified in some manner and his understanding of this very difficult and unsettled problem enlarged.

While no new idea has been advanced in this paper concerning protoplasm, some very interesting and illuminating statements have been introduced; and we have run the whole possible gamut from the notion that protoplasm is synonymous with cytoplasm to the other extreme which makes the unit of protoplasm coextensive with the cell. Pulling has injected the idea which one finds occasionally that we may not see protoplasm with our microscopes, this substance being perhaps so finely granular as to be ultramicroscopic. In view of diversity of opinion, it is questionable whether we had better say much about protoplasm, and even whether it might not be better to abandon the term and speak and write wholly in terms of cell structure. Chamberlain makes little use of the term, and Harper asked at Cincinnati, perhaps half in jest, whether we might not get on better without using the term protoplasm.

The position that protoplasm consists of cytoplasm and nucleoplasm is very indefinite since cytoplasm may mean anything from the more finely granular material of the cell outside the nucleus to the whole cell content outside the nucleus. It is probable that all those who took this view had the first position in mind; but Miss Stokey has given reasons why the position which would add plastids and some other inclusions which arise from division is much more tenable. This is the position taken by nearly two-thirds of the botanists who replied; and the writer is willing to modify his previous position and accept this tentatively, not because it is the majority opinion, but for reasons stated in this paragraph and elsewhere in this paper. Though accepting it for the time, the writer thinks that a view of protoplasm which stops short of the whole protoplast is so difficult to present to elementary students that he will probably be content to touch protoplasm lightly as the living substance of the cell and give the remainder of the discussions in terms of cell structure. In advanced classes he expects to treat protoplasm as a polyphase colloidal system, and state the various ideas regarding what portions of the cell may or may not be protoplasm. Of course all belongs to the complex colloidal system whether protoplasm or not.

Next in order, we may consider the not commonly accepted position which the writer held when he began this investigation, namely that the unit of protoplasm and the protoplast may be regarded as synonymous. This position rests, at least in part, on the facts that every part of the cell probably contains protoplasm at some time and that we have not yet made a good beginning of ascertaining what is and what is not alive, or what is and what is not protoplasm. The writer very reluctantly recedes from this position which is the most workable one that can be taken and has at the same time strong arguments in its favor. As brought out previously in this paper, the inclusion of the wall in the idea of the unit of protoplasm is the logical position for those who include the whole protoplast.

Two men, Buller and Mottier, were quite insistent at Cincinnati that protoplasm should be passed over as "the physical basis of life" or the living substance of the cell. Biologists can agree on this much. Dismissing the supposition that protoplasm may possibly be an attenuated ultramiscropic substance of which we know nothing, doubtless we will also agree that it is a complex colloidal substance, the chemistry of which is not yet thoroughly known. Beyond this, there is no agreement regarding protoplasm, except that cytoplasm or some portion of cytoplasm is protoplasm. A careful analysis of opinions of botanists quoted in this paper brings one to this peculiar conclusion. Consequently, no more inclusive position with respect to the physical content of protoplasm can be assumed certainly; and we should take our positions with great respect for the opinions of others.

How long we may have to continue in this uncertain state of mind respecting protoplasm is wholly problematical. Though most of our ideas of protoplasm are at present quite hypothetical, biologists and chemists have accomplished a good deal in this very difficult field of research. With further study, it seems probable that the fragments of knowledge may be rewoven from time to time until the woof of knowledge regarding protoplasm may be fairly complete.

In the present state of knowledge of protoplasm, the matter of prime importance is that we should not feel so certain of any position taken as to attempt to treat as established that which is quite uncertain. The few well established facts may

be stated with confidence. But the many points that are purely hypothetical should be handled in research and in teaching without attempting to hold any one position to the exclusion of the possibility of another one being preferable. If, then, rather than attempting the impossible in way of reaching some positive position, this paper may contribute to open mindedness respecting protoplasm, and suggest treatment commensurate with present knowledge, it will have accomplished the best possible service.

Finally, the writer wishes to express his very great appreciation of the aid given so generously by busy workers.

SOME OBSERVATIONS OF A PLANT COLLECTOR ON THE ISLAND OF HAINAN.*

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The island Hainan lies just off the coast of Kwangtung, the southermost province of China, in about the latitude of Porto Rico. It is about four times as large as that island, being roughly 150 miles long by 90 miles wide.

It has been a center of interest to the Chinese since early times, having furnished an important source of incense wood and drugs, two products traditionally very essential to the life of the Chinese people. Situated as it is just within the tropics and in close proximity to China, Indo-China, Formosa and the Philippines, and having high, densely wooded mountain ranges, Hainan has long been an inviting field to botanists. From time to time Western naturalists have visited the island. Few, however, have done more than briefly to skim the coastal plain for plant novelties.

Misfortune has so often been the lot of those who have attempted to penetrate to the interior of the island that a tradition of extreme inaccessibility has grown up around it. Started first by the Chinese soldiers whose comrades died by the hundreds of fevers and unfamiliar diseases when expeditions were sent to suppress the wild people in the interior, the stories of the unhealthfulness of the climate were confirmed by the westerners who have traveled there.

Of particular interest and fascination is the Five Finger Range of mountains which, being the highest and occupying a central location, offers a fruitful field to both the geographer and the botanist. Spurred by the unsuccessful and, in two instances, fatal attempts to reach the summit of this range, the late Mr. G. W. Pearson, then British Consul at Hoihow, set out on a journey in 1910 for the purpose of accomplishing that feat. He was well equipped in every way and was ac-

* From an illustrated lecture delivered before the Botany Section of the Ohio Academy of Science at Columbus, Ohio, April 19, 1924.

companied by a British lieutenant and Mr. Newton of the American Presbyterian Mission. They spent a month in the interior but returned baffled in their attempt, due to constant rain, fever and the reluctance of the natives to lend a hand. Mr. Pearson in his diary wrote very eloquently of the difficulties involved, and prophesied most interesting botanical and other discoveries for anyone who should overcome the obstacles that had so far proved insurmountable. It gave me therefore something of a thrill when the Canton Christian College sent me to Hainan, first in September, 1921, for the purpose of exploring its plant resources and of reaching, if possible, the summit of the Five Finger Range.

As to the topography of the island, the northern third is level or gently rolling, with an occasional extinct volcanic crater. The soil of the northeastern portion is obviously of volcanic origin. The southern two-thirds of the island is very mountainous, but I saw no craters there.

The inhabitants of the island comprise three distinct groups: the Chinese, the Miao and the Loi. The Chinese occupy all the farming lands which are most desirable from the point of view of fertility and accessibility. The Miao, an aboriginal people in the island, are still in a very primitive state, living by migratory agriculture and by hunting with bows and arrows. They live in the mountains and resist Chinese authority. The Loi are related to the Shans and Laos of Indo-China, and are thought to have come to Hainan in prehistoric times in search of the incense woods for which the island is famous. They are for the most part wild, resisting government by the Chinese. These primitive peoples of the interior have some intercourse with the Chinese as they come out on certain days to the border market towns to exchange their rattan and crop surplus for salt, colored yarn and a few other Chinese articles of trade. During the four months I spent on the Island I was mostly among the Loi aborigines near the Five Finger mountains.

Proceeding in a southwesterly direction from Hoihow, the chief seaport of the island, one passes thru fertile farming country, the soil of which is largely of volcanic origin. This region is occupied by Chinese and civilized Loi. The chief crops noted are: rice, both upland and irrigated, sugar cane, beans, indigo, peanuts, and here and there a field of scraggly

cotton. The Litchi thrives wonderfully in the stony country around the extinct volcanic craters. Coconut palms are very common. I saw one fine orchard of tea oil trees (*Thea Oleosa* Lour). The betel nut palm (*Areca catechu* L) is grown extensively in the eastern portion of the island along the Kachek River. At about 75 miles southwest of Hoihow one reaches Nam Fung, the last Chinese outpost on the northern edge of the interior country inhabited by the wild Loi.

The agriculture of the Loi is exceedingly primitive, and being semimigratory in part, results in the complete desruction of the virgin forests everywhere except on the upper slopes of the mountains. Where wet rice culture is practiced the terraces are not plowed but treaded into the proper consistency with water buffalo. A most striking practice is that the grain is stored in granaries in the head and threshed meal by meal, just as it is needed!

As regards the plants used by the Loi for different purposes, they are mostly the same as those used by the Chinese generally. Rice is their main crop, and to it they give their most serious attention. They cultivate many varieties, both irrigated and dry land, starchy and glutinous, red grained, white grained, and red bearded. They grow also some flint corn and sweet potatoes. They now and then have a little patch of raggee (*Eleusine coracana* Gaert), cassava (*Manihot utilissima* Pohl), Job's tears (*Coix lachryma-jobi* L.) or *Sesamum orientale*. Their vegetable gardens are given over mostly to tobacco and isolated specimens of plants such as *Rumex sp.*, and *Celosia sp.* and others which are supposed by them to possess medicinal value. *Basella rubra L* is found rather commonly, and serves as a vegetable. They usually have a few red peppers of which I saw now and then a white variety. About the only vegetable they cultivate with any care or regularity is the pumpkin. Nearly every hut has its pumpkin arbor whereon the vines grow profusely. The flowers and young leaves are cooked and eaten, as well as the fruit both green and mature. They also cook and eat the young fruits of *Carica papaya* L. They sometimes use as vegetables the green leaves of *Iresine herbstii* Hook and a variety of other wild herbs, including other Amarantaceae, the heart of the wild banana plant (*Musa para disiacea var seminifersa* (Lour) Baker) and a pungent, spiny little herb,

Eryngium foetidum I tried them all—and found them better than none.

Fruits they do not cultivate seriously. But nearly every village has a tree or two of jackfruit (*Artocarpus integrifolia* L), pomelo (*Citrus decumana* Murr), and occasionally a litchi, mango or tamarind tree. The Loi seem to relish fruits, and knows every wild fruit that is edible. From the wild they get garcinias, rose apples, litchi, a small citrus fruit, large figs and many others.

In their simple lamps they use the oil expressed from the seeds of castor bean (*Ricinus communis* L), the physic nut (*Jatropha curcas* L) the wood oil tree (*Aleurites moluccana* (L) Wild), the domba oil tree (*Calophyllum inophyllum* L) and the tea oil tree (*Thea Oleosa* Lour). These plants are all semi-cultivated.

The fruiting heads of Thysanolena maxima are stripped of their seeds and bound together with split rattan into brooms. *Imperata cylindrica* Beaur is the grass always used to thatch their roofs. The bamboos (*Bambusa spp.*, *Dendrocalamus spp.*, and *Schizostachyum spp.*) both cultivated and wild, are indispensible to these people.

As to their relatives on the mainland, they use the sap of the sack tree (*Antiaris toxicaria* Lesch.) in preparing an arrow poison. They make a blue dye from the leaves of *Strobilanthes flaccidifolius* Nees, while the Chinese use a species of Indigoferum or Polygonum. For thread and cloth they use the fibres from *Gossypium hirsutum* L. *var arborescens* a tall perennial shrub which grows half cultivated around most of the villages. The coarse fibres of two species of Helicteres, of *Abroma augusta* L. and others are also used. *Boehmeria nivea* Gaudich is sometimes cultivated for its fibres. The ribbon-like leaves of *Pandanus spp.* are woven into hats and coarse matting. *Cyperus tegetiformis* Benth is used also in making matting. The leaves of several species of Licuala are dried and used to make raincoats. One of the most useful wild plants found in Hainan is the rattan. Several species of Calamus are gathered by the Loi for their own use as well as for the market. The raised floors of their houses are made from it. It provides tough thongs with which to bind the house frames together, to make bow strings and to mend many things.

One of the most prominent and beautiful trees occurring in the open, deforested country is the Formosan sweet gum (*Liquidambar formosana* Hance). Upon these trees there lives a species of wild silk worm from whose silk glands the silk gut of commerce is made by a very interesting process.

The known flora of Hainan had been, up to the time of my exploration there, only 370 species. My collections increased that number to 1375 species, an addition of about a thousand species. The complete collection contains 2231 numbers, representing 1118 species, which are distributed in about 150 families and 660 genera. Of these nearly 100 species are new to science. One family, Ochnaceae, of 38 known genera and many species was reported from China for the first time. Dr. E. D. Merrill, until lately Director of the Philippine Bureau of Science, determined the plants with the exception of the grasses, which were determined by Dr. A. S. Hitchcock, and the orchids, which were determined by Mr. Oakes Ames.

Among the plants collected were many of economic promise, such as lumber plants, drug plants, textile plants, food plants and many promising ornamentals. Many of the new species are of special interest, of which Taractogenos hainanensis Merr, a new member of the famous Chaulmoogra oil-yielding group (Flacourtiaceae); *Ficus palmatiloba* Merr., closely related to our cultivated fig; and *Schizostachyum hainanense* Merr., a climbing bamboo, are worthy of mention. There were also: a new Pandanus, two new Licualas, several new members of the Ginger family, a new Quercus, a new Castanopsis, a new Piper, two new Kadsuras (Magnoliaceae), two new Polyalthias and three new Fissistigmas (Annonaceae), seven new members of the Lauraceae, of which three are Cryptocaryas, and many others.

I was able to make only a light impression on the flora of the island during the 120 days I spent there. The other high and extensive mountain ranges which have never been touched will doubtless yield another thousand or possibly two thousand species.

I succeeded in reaching the top of the Five Finger Range and found the altitude of its highest peak to be 7300 feet.

DESCRIPTIONS OF FOURTEEN UNDESCRIBED SPECIES OF PARTHENICUS (HEMIPTERA, MIRIDÆ).*

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The following descriptions cover material collected by the writer during 1917, chiefly in Arizona, while a member of the Cornell University biological expedition, combined with material collected in the same state during 1924, by Mr. Andrew A. Nichol. Paratypes, where available, will be deposited in the Cornell University collection and in the Arizona Agricultural Experiment Station collection.

Parthenicus nicholi new species.

Allied to *vaccini* V. D., but distinguished by the opaque white color, paler femora with minute fuscous dots only, and by the orange red mark on membrane bordering inner apical angles of corium.

♂. Length, 2.7 mm., width 1.08 mm. Head: width .57 mm., vertex .28 mm. Rostrum, length 1 mm., reaching upon base of genital segment. Antennæ: segment I, length .20 mm., white, a transverse black mark on dorsal surface at slightly beyond middle, formed by blackish occurring at base of three setæ; II, .80 mm., pale, with seven to nine black dots strung out on dorsal surface; III, .54 mm., pale; IV, (shriveled) dusky. Pronotum: length .40 mm., width at base .91 mm. Color white, opaque, head yellowish, mesoscutum and base of scutellum dusky; nearly all pubescent hairs except those on head with a blackish dot formed at base, the spots larger and more prominent anteriorly and laterally on pronotal disk; membrane pale whitish, lateral margins with two fuscous spots much as in *vaccini*, but in addition with several pale fuscous spots on discal area; anal area fuscous, veins white, cubitus red at base which joins with small orange red area bordering inner apical angles of corium. Ventral surface yellowish to white, sternum dusky. Legs white, femora with minute fuscous dots which form at base of certain pubescent hairs, one larger subapical spot on dorsal area; tibial spines with prominent black spots at base, claws black. Dorsum clothed with suberect, white pubescence, and intermixed with prostrate, silvery sericeous pubescence, some of which changes to pale golden on corium;

* Contribution from the Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

a tuft of black scales on corium at apex of clavus, also two or three smaller tufts of black scales along inner cuneal margin.

♀. Length, 2.6 mm., width, 1.08 mm.; slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, June 11, 1924, Santa Catalina Mts., Arizona (A. A. Nichol); author's collection. *Allotype:* Same data as the type. *Paratypes:* 3 ♂, 3 ♀, taken with the types; found breeding on *Hyptis emoryi* by Mr. Nichol.

I take great pleasure in naming this beautiful little species after the collector, Mr. Andrew A. Nichol, who, in addition to being one of the Immortals at Bellou Wood, and still fighting to regain his health after being gassed in the war, is now proving himself an excellent collector and capable entomologist.

Parthenicus albellus new species.

Allied to *vaccini* V. D., but differs in the uniformly greenish white color, silvery white sericeous pubescence, with a tuft of black scales on corium at apex of clavus, and in the conspurcate membrane.

♂. Length 2.8 mm., width .97 mm. Head: width .54 mm., vertex .26 mm. Rostrum, length 1.2 mm., reaching upon base of genital segment. Antennæ: segment I, length .18 mm., pale greenish, a transverse fuscous mark on dorsal surface at slightly beyond middle; II, .84 mm., pale, dorsal surface narrowly fuscous at base, also a spot situated at middle of basal half; III, .60 mm.; IV, .31 mm., dusky. Pronotum: length .34 mm., width at base .83 mm. Pale whitish, tinged with green on head, pronotum, and ventral surface; membrane white, thickly conspurcate with fuscous marks which coalesce more or less to form larger irregular spots, the largest dark spot on margin near apex, while a smaller one occurs just beyond apex of cuneus; veins white. Legs white, femora with pale fuscous dots and marks; tibiæ with fuscous spot at base of each spine, but spots nearly obsolete on hind pair. Dorsum clothed with simple, suberect pale pubescence, longest on head, margins of pronotum, and costal margins; intermixed with prostrate, silvery sericeous pubescence, with a few pale golden yellow sericeous hairs on corium; a tuft of black scales on corium at apex of clavus, also a few darker scales at middle of inner margin of cuneus.

♀. Length 2.6 mm., width 1.08 mm.; more robust than the male with costal margin slightly arcuate, but very similar in pubescence and coloration.

Holotype: ♂, October 21, 1924, Pima Co., Arizona, (A. A. Nichol); author's collection. *Allotype:* Same data as the type. *Paratypes:* 7 ♂ ♀, taken with the types.

Parthenicus selectus new species.

Allied to *nicholi*, but differs in having discal area of membrane uniformly white and in lacking the orange red color bordering anal area; pronotal disk and hind femora with a few red dots; antennal segment II with obsolete fuscous dots.

♂. Length 3.5 mm., width 1.36 mm. *Head:* width .60 mm., vertex .26 mm. Rostrum, length 1.17 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .21 mm.; II, .94 mm.; III, .60 mm.; IV, .31 mm.; segment II with two or three obsolete fuscous dots near base, not distinctly marked with several black spots as in *nicholi* or *vaccini*. Pronotum: length .41 mm., width at base, 1 mm. Coloration very suggestive of *nicholi*, but ground color paler white; membrane uniformly white on disk, having only two fuscous areas each side on the margin; pronotal disk anteriorly, vertex, and hind femora bearing reddish dots, the femora also with fuscous points on apical half. Dorsum clothed with simple white pubescence as in *nicholi*, but more thickly intermixed with prostrate, golden and silvery sericeous pubescence, without black scales behind apex of clavus, although with dark bronze colored scales there and along inner margin of cuneus; basal half of scutellum with a few blackish scales each side mixed in with silvery sericeous pubescence.

Holotype: ♂, April 19, 1924, Tucson, Arizona, (A. A. Nichol); author's collection. *Paratypes:* 2♂, taken with the type. ♂, June 7, 1924, Tucson, Arizona, (A. A. Nichol).

Parthenicus pictus new species.

Allied to *giffardi* V. D., but size smaller, differs in the deeply colored roseate cuneus and apical area of corium, and by the silvery and golden sericeous pubescence.

♂. Length 2.9 mm., width 1.1 mm. Head: width .63 mm., vertex .23 mm. Rostrum, length 1.08 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .18 mm.; II, 1.03 mm.; III, .64 mm.; IV, .33 mm.; pale greenish, last two segments dusky. Pronotum: length .46 mm., width at base .91 mm. Head, pronotum, and body beneath green, sternum, vertex, and sometimes on pronotal disk, yellowish; basal two-fifths of clavus and corium, scutellum and apical angle of corium roseate red, scutellum darker; apical half of clavus pale yellowish, apical half of corium pale fuscous. Membrane uniformly dark fuscous, slightly paler bordering cuneus, veins bright red. Dorsum clothed with prostrate, silvery sericeous pubescence; apical half of clavus except apex, clothed with golden sericeous pubescence, corium with inner apical edge, point on middle and one at basal angle of inner margin of cuneus, set with fuscous to golden scale-like pubescence, also a few similar hairs on scutellum; hemelytra with sparsely set fuscous

pubescent hairs intermixed with the sericeous pubescence, the simple hairs being more prominent and silvery white on head and anterior margin of pronotum. Legs green, apical half with red and fuscous markings over a paler ground; tibiæ pale, with fuscous points at base of spines, hind pair with red points on basal two-fifths; tarsi dusky. Genital claspers tinged with red, form very near that of *psalliodes* Reuter.

♀. Length 2.8 mm., width 1.07 mm. Head: width .57 mm., vertex .31 mm. Antennæ: segment I, length .18 mm.; II, .93 mm.; III, .64 mm.; IV, .34 mm. Slightly more robust than the male, but very similar in coloration.

Holotype: ♂, September 25, 1924, Santa Catalina Mts., Arizona (A. A. Nichol); author's collection. *Allotype:* August 19, 1924, Sierrita Mts., Arizona (A. A. Nichol). *Paratypes:* 3♂, 1♀, taken with the allotype. ♀, June 15, 1924, Santa Rita Mts., alt. 4,500 ft., Arizona (A. A. Nichol). ♀, October 21, 1924, Pima Co., alt. 3,000 ft., Arizona (A. A. Nichol). ♀, July 16, 1917, Post Creek Canyon, Bonita, Arizona (H. H. Knight). ♂, ♀, July 20, 1917, Texas Pass, Arizona (H. H. Knight).

Parthenicus oreades new species.

Allied to *giffardi* V. D., but differs in the golden sericeous pubescence on clavus and corium, and in the red dotted pronotal disk with similar dotted area on middle of corium opposite apical area of clavus.

♂. Length 3.7 mm., width 1.28 mm. Head: width .66 mm., vertex .28 mm. Rostrum, length 1.07 mm., reaching upon fourth or fifth ventral segments. Antennæ: segment I, length .34 mm.; II, 1.14 mm.; III, .73 mm.; IV, .34 mm.; pale, segment I with a few minute flecks of red, apical segment scarcely dusky. Pronotum: length .51 mm., width at base 1.11 mm. Dorsum pale whitish, pronotal disk flecked with reddish, more thickly and with coalescing areas at sides; scutellum dark red, tip pale; clavus red at base for nearly length of scutellum, but edges breaking into dots; narrow base of corium and embolium, area on corium which includes apex of clavus, dotted with irregular flecks of red; inner apical angles of corium red, inner basal angles of cuneus thickly flecked with red. Membrane uniformly fuscous, a small clear spot by apex of cuneus; veins red, bordering apex of areoles white. Dorsum clothed with prostrate, silvery sericeous pubescence, clavus except base and apex, and corium largely except area surrounding apex of clavus, clothed with golden yellow sericeous pubescence; a smaller area at inner apical angles of corium as well as disk of scutellum, set with golden and blackish sericeous pubescence; head and margins of pronotum set with prominent white to yellow hairs. Head with sides and tylus chiefly red; sides of thorax reddish to fuscous, venter flecked with red on

the sides. Legs pale yellowish, femora with red, hind pair chiefly red, but broken by minute whitish reticulations; tibiæ with red dots at base of spines, becoming obsolete on apical half.

♀. Length 3.3 mm., width 1.28 mm. Head: width .63 mm., vertex .36 mm. Antennæ segment I, length .20 mm.; II, 1.03 mm.; III, .70 mm.; IV, .36 mm. Pronotum: length .48 mm., width at base 1. mm. Slightly more robust than the male, but very similar in coloration.

Holotype: ♂, July 18, 1917, Gowdy Creek Canyon, alt. 4,500 ft., Bonita, Arizona (H. H. Knight); author's collection. *Allotype:* Taken with the type; Cornell University collection. *Paratypes:* ♂, ♀, taken with the types. ♂, ♀, June 15, 1924, Santa Rita Mts., alt. 4,500 ft., Arizona (A. A. Nichol).

Parthenicus micans new species.

Suggestive of *oreades*, but size smaller, distinguished by the uniformly silvery white, scale-like pubescence on clavus and corium, with golden scale-like hairs only at inner apical angles of corium.

♂. Length 2.7 mm., width 1.14 mm. Head: width .63 mm., vertex .26 mm. Rostrum, length 1.06 mm., reaching upon fourth ventral segment. Antennæ: segment I, length .18 mm.; II, .86 mm.; III, .57 mm.; IV, .31 mm., uniformly pale yellowish, scarcely dusky on last segment. Pronotum: length .43 mm., width at base .88 mm. Dorsum creamy white, cuneus more strongly yellow and flecked with bright red, sometimes nearly all red; lateral margins of pronotum, base of corium, and frequently base of clavus, flecked with red, sometimes with a few scattering flecks of red on middle of corium; head yellowish and tinged with red. Dorsum clothed with prostrate, silvery white, scale-like pubescence, scutellum with spot each side on basal half clothed with bronze-colored scale-like hairs, inner apical angles of corium clothed with bronze to golden scale-like hairs which continue along inner margin of cuneus, but with a few blackish scales at two points; whole dorsum intermixed with nearly erect pale pubescent hairs, but more prominent on head, margins of pronotum and hemelytra. Membrane uniformly fusco-brownish, a pale spot bordering apex of cuneus; veins bright red, a white spot at apex of larger areole. Legs pale to yellowish, femora with small red dots on apical half, hind pair thickly dotted with red to fusco-reddish; tibiæ pale, with red dots at base of spines, but becoming obsolete on apical half, spines white, prominent, length of those near base equal to three times diameter of tibia. Sides of thorax and venter yellowish, dorsal half of propleura more or less red, sometimes the red showing on meso- and metapleura; venter pale pubescent, sides clothed with silvery white, scale-like pubescence.

♀. Length 2.6 mm., width 1.13 mm.; slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, July 21, 1917, Santa Cruz river, Tucson, Arizona (H. H. Knight), collected at light; author's collection. *Allotype:* Taken with the type; Cornell University collection. *Paratypes:* 4 ♂, 4 ♀, taken with the types at light. 2 ♀, June 7, 1924, Tucson, Arizona (A. A. Nichol). ♀, July 20, 1917, Texas Pass, Arizona (H. H. Knight). ♀, July 2, 1917, Sabinal, Texas (H. H. Knight).

Parthenicus irroratus new species.

Size and color nearest to *psalliodes* Reut., but distinguished from all described species by the fuscous membrane with numerous white irrorate spots.

♂. Length 3.6 mm., width 1.03 mm. Head: width .61 mm., vertex .23 mm.; tylus very prominent, distinctly compressed. Rostrum, length .98 mm., just about attaining posterior margins of hind coxæ. Antennæ: segment I, length .27 mm.; II, .93 mm.; III, .74 mm.; IV, .33 mm.; pale yellowish and marked with reddish, segment I flecked with red, while segment II is more or less broadly tinged with red on apical half. Pronotum: length .43 mm., width at base .90 mm. Color pale testaceous and tinged with greenish, dorsum rather evenly flecked with reddish much as in *psalliodes*, cuneus darker on basal half; membrane fuscous, rather numerously marked with irrorate white spots, largest spots little greater than diameter of tibia. Dorsum clothed with suberect, simple, pale pubescence, longest on head and margins of pronotum; intermixed with golden and silvery pubescence, inner apical angles of corium and two points along inner margin of cuneus set with a few black scales; the fuscous basal half of scutellum also with a few dark scales. Sternum fuscous, pleura and coxæ greenish, venter greenish and rather thickly flecked with red. Femora marked with fuscous and fusco-reddish, the black marks and dots showing most clearly on dorsal aspect of apical half of hind femora, the ventral surface flecked with red; tibiæ pale, with red spots at base of spines.

♀. Length 2.9 mm., width 1.03 mm.; shorter and slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, March 22, 1924, Tucson, Arizona (A. A. Nichol); author's collection. *Allotype:* July 16, 1917, Post Creek Canyon, Bonita, Arizona (H. H. Knight), collected at light.

Parthenicus rubrinervis new species.

Distinguished by the uniformly yellowish or greenish yellow color, pale pubescence, and pale fuscous membrane with bright red veins.

♂. Length 2.7 mm., width 1.1 mm. Head: width .66 mm., vertex .19 mm. Rostrum, length 1.11 mm., only slightly exceeding posterior margins of hind coxæ. Antennæ: segment I, length .20 mm.; II, .97 mm.; III, .57 mm.; IV, .32 mm.; uniformly pale yellowish. Pronotum: length .43 mm.; width at base .86 mm. Pale yellowish to greenish yellow, eyes reddish; membrane uniformly light fuscous, veins bright red; clothed with silvery white, sericeous or scale-like pubescence, two points on inner margin of cuneus with black scale-like hairs; the whole dorsum also clothed with longer, more erect, pale yellowish pubescent hairs. Legs pale yellowish, femora with minute pale fuscous ring around base of each hair; tibiæ with obscure fuscous spot at base of each spine; tarsi pale, claws black. Genital claspers distinctive, right clasper terminating with a slender acuminate point at apex of dorsal margin.

♀. Length 2.7 mm., width 1.17 mm.; slightly more robust than the male, but similar in pubescence and coloration.

Holotype: ♂, July 20, 1917, Texas Pass, Arizona (H. H. Knight); author's collection. *Allotype:* Same data as type. *Paratype:* ♂, taken with the types.

Parthenicus baccharidis new species.

Allied to *psalliodes* Reut., but distinguished by the general pale color, impunctate hind tibiæ, although with minute fuscous dots on hind femora; silvery pubescent, but with golden sericeous pubescence on clavus and corium.

♂. Length 2.7 mm., width 1.03 mm. Head: width .63 mm., vertex .23 mm. Rostrum, length 1 mm., scarcely exceeding posterior margins of hind coxæ. Antennæ: segment I, length .20 mm.; II, .88 mm.; III, .63 mm.; IV, .33 mm. Pronotum: length .43 mm., width at base .86 mm. Color pale testaceous white, eyes reddish, basal half of scutellum slightly darkened, also dusky at inner apical angles of corium; membrane uniformly pale fuscous, veins pale, two orange flecks on apex of areoles. Femora with minute fuscous dots, one at base of each pubescent hair, obsolete ventrally; intermediate femora with reddish marks appearing on ventral surface; tibiæ pale, with fuscous dots at base of spines except on hind pair. Clothed with pale to yellowish simple pubescence, intermixed with more thickly set, prostrate, silvery sericeous pubescence, clavus except base and apex, corium, and cuneus, set with golden sericeous pubescence; inner apical angles of corium and inner margin of cuneus set with bronze to dusky scale-like pubescence. Genital claspers very similar to those of *psalliodes* Reuter.

♀. Length 2.7 mm., width 1.08 mm. Head: width .57 mm., vertex .28 mm. Antennæ: segment I, length .18 mm.; II, .91 mm.; III, .60 mm.; IV, .31 mm. Pronotum: length .40 mm., width at base .86 mm. Similar to the male in pubescence and coloration.

Holotype: ♂, July 23, 1917, Sabino Canyon, Alt. 3,000 ft., Tucson, Arizona (H. H. Knight); author's collection. *Allotype:* Same data as the type. *Paratypes:* ♂, 4 ♀, taken with the types and found breeding on *Baccharis emoryi.*

Parthenicus rubromaculosus new species.

Allied to *psalliodes* Reut., but size smaller; differs in the densely red-flecked hemelytra combined with nearly pale pronotum; inner apical angles of corium without fuscous or dark pubescence.

♂. Length 2.5 mm., width 1 mm. Head: width .57 mm., vertex .27 mm. Rostrum, length 1.11 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .18 mm.; II, .80 mm.; III, .57 mm.; IV, .31 mm.; pale yellowish, last two segments dusky. Pronotum: length .40 mm., width at base .86 mm. Head and pronotum pale to yellowish, head and margins of pronotum obsoletely flecked with reddish yellow; scutellum and hemelytra densely flecked with light red, the flecks coalescing to form larger irregular spots; cuneus thickly flecked like the corium, but with brighter red. Membrane fusco-brownish, paler bordering cuneal margin, veins bright red, a pale point at apex of larger areole. Dorsum clothed with pale to yellowish simple pubescence, intermixed with silvery sericeous pubescence, but chiefly golden sericeous pubescence on hemelytra; inner margin of cuneus with point at middle and one at base with a few darker scale-like hairs. Legs yellowish, femora flecked with red points, the hind pair with numerous minute pale fuscous points, one at base of each pubescent hair; tibial spines pale, with red points at base, although nearly obsolete on hind pair.

♀. Length 2.5 mm., width 1.11 mm.; slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, July 20, 1917, Texas Pass, Arizona (H. H. Knight); author's collection. *Allotype:* Taken with the type at light; Cornell University collection. *Paratypes:* 8 ♂ ♀, taken with types. ♂, August 29, 1924, Santa Rita Mts., alt. 4,500 ft., Arizona (A. A. Nichol).

Parthenicus rufusculus new species.

Allied to psalliodes Reut., but size slightly larger; distinguished by the general fusco-reddish coloration.

♂. Length 3.6 mm., width 1.43 mm. Head: width .71 mm., vertex .23 mm. Rostrum, length 1.29 mm., reaching upon the fourth ventral segment, reddish orange, fuscous apically. Antennæ: segment I, length .21 mm.; II, 1.08 mm.; III, .61 mm.; IV, broken; yellowish with

a tinge of reddish, rather uniformly clouded by fuscous. Pronotum: length .53 mm., width at base 1.17 mm. Coloration fusco-reddish, an orange red hypodermal color clouded over by fuscous, cuneus more distinctly red, scutellum distinctly blackish, in darkest specimens the dorsum rather uniformly fuscous, which nearly obscures the reddish; thorax and coxæ rather uniformly fuscous, venter greenish yellow and darkened with fuscous. Legs greenish yellow to reddish, femora darkened by numerous small fuscous points, one such spot at base of each pubescent hair; tibial spines yellowish, a fuscous point at base of each. Membrane uniformly fuscous, a narrow pale area at apex of cuneus; veins orange red, a pale point on apex of larger areole. Dorsum clothed with prostrate, golden yellow sericeous or scale-like pubescence, some turning to black at inner apical angles of corium and along inner margin of cuneus, the whole dorsum more sparsely clothed with suberect, simple yellowish pubescence.

♀. Length 3.4 mm., width 1.2 mm. Head: width .63 mm., vertex .31 mm. Antennæ: segment I, length .17 mm.; II, .87 mm.; III, .58 mm.; IV, .33 mm. Pronotum: length .46 mm., width at base 1 mm. Shorter and slightly more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, April 5, 1924, Tucson, Arizona (A. A. Nichol); author's collection. *Allotype:* Same data as type. *Paratypes:* ♂, February 9, 2 ♀, February 16, ♀ April 5, ♀ April 12, 1924, Tucson, Arizona, (A. A. Nichol).

Parthenicus aureosquamis new species.

Evidently most closely related to *percroceus* V. D., but differs in the golden, scale-like pubescence of the dorsum; veins of membrane red, their apex white; femora with fine pale fuscous dots, these spots becoming reddish on ventral surface.

♂. Length 2.8 mm., width 1.08 mm. Head: width .66 mm., vertex .24 mm. Rostrum, length, 1.14 mm., reaching upon fifth ventral segment. Antennæ: segment I, length .20 mm.; II, .86 mm.; III, .54 mm.; IV, .27 mm.; yellow, sometimes tinged with reddish. Pronotum: length .43 mm., width at base .91 mm. Color reddish yellow to orange red, in darkest specimens the hemelytra except embolium becoming strongly red; scutellum slightly darker than clavus. Membrane uniformly fuscous, veins red, a white point at apex of areoles. Dorsum clothed with golden yellow simple pubescence, intermixed with thickly set, prostrate, sericeous and scale-like golden pubescence, membrane margin and a tuft at inner apical angles of corium, set with darker scale-like pubescence; a transverse area across apex of clavus and reaching middle of corium, inner basal angles of cuneus, claval margins of scutellum, and anteriorly on pronotum, set with silvery scale-like pubescence. Ventral surface and legs yellowish to reddish

yellow, hind femora darkened with numerous, minute pale fuscous points; tibial spines yellowish, a fuscous spot at base of each, becoming obsolete on hind tibiæ.

♀. Length 2.7 mm., width .86 mm.; more robust than the male, but very similar in pubescence and coloration.

Holotype: ♂, July 20, 1917, Texas Pass, Arizona (H. H. Knight); author's collection. *Allotype:* Taken with the type; Cornell University collection. *Paratypes:* 22 ♂ ♀, taken with the types at trap light. ♂, July 16, 1917, Post Creek Canyon, Bonita, Arizona, (H. H. Knight). 8 ♂ ♀, June 7, 1924, Tucson, Arizona, (A. A. Nichol), on *Covillea* sp. ♂, July 21, 1917, between Texas Pass and Tucson, Arizona, (H. H. Knight), on *Covillea* sp. 5 ♂, July 13, 1917, Lordsburg, New Mexico, (H. H. Knight), at light. ♂, July 28, 1914, El Paso, Texas, (J. C. Bradley).

Parthenicus rufivenosus new species.

Distinguished from all other described species by the bright green hemelytra with fuscous membrane and red veins.

♀. Length 3.4 mm., width 1.34 mm. Head: width .66 mm., vertex .37 mm. Rostrum, length 1.21 mm., extending slightly beyond hind margins of posterior coxæ. Antennæ: segment I, length .28 mm.; II, 1.10 mm.; III, .77 mm.; IV, .38 mm.; greenish yellow, last segment dusky. Pronotum: length .51 mm., width at base 1.01 mm. Color greenish yellow, hemelytra and basal half of pronotum bright green, inner margin of cuneus bordering smaller areole bright red; membrane uniformly fuscous, slightly paler bordering apex of cuneus, veins bright red. Dorsum clothed with prostrate, silvery and dark bronze, sericeous pubescence, and intermixed with pale, more erect simple pubescence. Legs and ventral surface uniformly greenish yellow, tibiæ impunctate.

♂. Length 3.3 mm., width 1.26 mm. Similar to the female in pubescence and coloration. Antennæ and one wing mutilated in this specimen. Genitalia distinctive, the right clasper V-shaped, the apical half slightly more slender than basal half, slightly flattened and acuminate at tip.

Holotype: ♀, July 18, 1917, Gowdy Creek Canyon, Bonita, Arizona, (H. H. Knight); author's collection. *Allotype:* ♂, June 15, 1924, Santa Rita Mts., Arizona, (A. A. Nichol); author's collection. *Paratypes:* ♀, taken with type. ♀, taken with the allotype.

Parthenicus cuneotinctus new species.

Aspect of *rufivenosus*, but paler green in color; veins in membrane pale and spotted with red, cuneus broadly tinted with roseate-red; tibial spines with fuscous spots at base.

♀. Length 2.6 mm., width 1.06 mm. Head: width .56 mm., vertex .34 mm. Rostrum, length 1.04 mm., reaching to fifth ventral segment. Antennæ: segment I, length .20 mm.; II, .83 mm.; III, .54 mm.; IV, .31 mm. Pronotum, length .40 mm., width at base .91 mm. Color pale green, obsoletely maculated with pale yellow; head, anterior margin of pronotum, scutellum, and embolium, paler. Cuneus largely tinted with roseate-red. Membrane pale fuscous, paler within areoles and at apex of cuneus; veins pale to white, flecked with red. Pale pubescent, more densely clothed with prostrate, silvery scale-like pubescence; area on middle of corium and clavus, and inner apical angles of corium, clothed with golden scale-like pubescence, a few darker scales forming a point at middle of inner margin of cuneus and on basal angle. Ventral surface pale to greenish, venter pale pubescent and intermixed with silvery scale-like pubescence. Legs pale greenish, apical half of hind femora with pale yellow showing at base of pubescent hairs, a few obsolete or pale fuscous points on dorsal surface; tibial spines pale with fuscous spot at base of each, the spots more brownish on hind pair.

Holotype: ♀, August 19, 1924, Sierrita Mts., Arizona, (A. A. Nichol); author's collection. Mr. Nichol found this specimen on *Croton corymbulosus*.

ADDITIONS TO THE CATALOG OF OHIO VASCULAR PLANTS FOR 1924.*

JOHN H. SCHAFFNER
Department of Botany, Ohio State University

The following list of species is based on specimens presented to the Ohio State Herbarium during the past year and not only adds a number of species new to the state, but extends our knowledge of local distribution materially. Mr. Len. Stephenson has contributed an interesting collection from a locality known locally as "Buffalo Beat," near Buchtel, Athens County.

39a. *Polystichum acrostichoides schweinitzii* (Beck) Small. Buchtel, Athens Co. Len. Stephenson.

55. *Equisetum silvaticum* L. Wood Horsetail. "In a marshy woodland" south of Harpersfield, Ashtabula Co. Arthur R. Harper.

70. *Pinus virginiana* Mill. Scrub Pine. Ten miles east of West Union, Jefferson Twp., Adams Co. John H. Schaffner and C. K. Kao.

121. *Typha angustifolia* L. Narrow-Leaf Cat-tail. Buchtel, Athens Co. Len. Stephenson.

139.1. *Cyperus ovularis* (Mx.) Torr. Globose Cyperus. "Grassy swale," along Higby Pike, Pike Co. Arthur R. Harper.

158. *Stenophyllus capillaris* (L.) Britt. Hair-like Stenophyllus. East of Barnesville, Belmont Co. Emma E. Laughlin.

265. *Carex haydeni* Dew. Hayden's Sedge. Castalia, Erie Co. E. L. Moseley.

328. *Poa autumnalis* Muhl. Flexuous Spear-grass. Along Clear Creek, between Sugar Grove and Rock Bridge, just within Hocking Co. James S. Hine.

337. *Eragrostis purshii* Schrad. Pursh's Love-grass. East of Barnesville, Belmont Co. Emma E. Laughlin.

340. *Eragrostis capillaris* (L.) Nees. Capillary Love-grass. East of Barnesville, Belmont Co. Emma E. Laughlin.

* Papers from the Department of Botany, The Ohio State University, No. 157.

361. *Lolium multiflorum* Lam. Awned Darnel. Clifton, Greene Co. Arthur R. Harper.

384. *Sporobolus vaginaeflorus* (Torr.) Wood. Sheathed Rush-grass. "Wayside," Barnesville, Belmont Co. Emma E. Laughlin.

404. *Muhlenbergia tenuiflora* (Willd.) B. S. P. Slender Muhlenbergia. Washington Twp., Highland Co. Katie M. Roads.

411. *Aristida oligantha* Mx. Few-flowered. Triple-awned-grass. "Roadside between Lore City and Old Washington," Guernsey Co. Emma E. Laughlin.

412. *Aristida gracilis* Ell. Slender Triple-awned-grass. "Edge of woods," south of Barnesville, Belmont Co. Emma E. Laughlin.

428. *Panicum depauperatum* Muhl. Starved Panic-grass. "Edge of dry wood." Washington Twp., Highland Co. Katie M. Roads.

448a. *Panicum boscii molle* (Vas.) Hitch. & Ch. Bosc's Panic-grass. Washington Twp., Highland Co. Katie M. Roads.

471a. *Andropogon scoparius* Mx. Little Bluestem. Extremely white glaucous variety. Jefferson Twp., Adams Co. John H. Schaffner.

504. *Trillium declinatum* (Gr.) Gleason. Drooping Trillium. "Edge of woods." Liberty Twp., Highland Co. Martha J. Mercer and Katie M. Roads. Also near Belfast, Jackson Twp., Highland Co. Martha J. Mercer.

532.1. *Commelina communis* L. Asiatic Day-flower. Buchtel, Athens Co. Len. Stephenson.

545. *Juncus torreyi* Cov. Torrey's Rush. Barnesville, Belmont Co. Emma E. Laughlin.

577. *Blephariglottis lacera* (Mx.) Farw. Ragged Fringed-orchis. Minford, Scioto Co. Arthur R. Harper.

580. *Blephariglottis peramoena* (Gr.) Rydb. Fringeless Purple Orchis. Piketon, Pike Co. Arthur R. Harper.

587. *Ibidium plantagineum* (Raf.) House. Broadleaf Lady's-tresses. Cedar Swamp, Champaign Co. Arthur R. Harper.

619. *Ranunculus obtusiusculus* Raf. Lance-leaf Buttercup. Gallipolis, Gallia Co. Arthur R. Harper.

657. *Berberis vulgaris* L. Common Barberry. In the original catalog (1914) this plant was said to be "Escaped rather generally." According to John W. Baringer, State Leader of barberry eradication in Ohio, barberry has been planted here and there, both in towns and in the country, all over Ohio. In the northwestern two-thirds of the state, which has been covered by the barberry eradication survey, it has been found as an escape, often abundant, in nearly all of the counties. Local botanists should assist as much as possible in educating the public on the importance of eliminating this undesirable plant from the state.

658. *Odostemon aquifolium* (Pursh) Rydb. Trailing Mahonia. Near Richfield, Summit Co. Introduced in some unknown way. Now eradicated.

667. *Papaver dubium* L. Corn Poppy. Along B. & O. Railway, near Hillsboro, Liberty Twp., Highland Co. Katie M. Roads.

687. *Camelina sativa* (L.) Crantz. Common False-flax. "A large patch along railway track" near Hillsboro, Liberty Twp., Highland Co. Katie M. Roads. Also Barnesville, Belmont Co. Emma E. Laughlin.

688. *Camelina microcarpa* Andrz. Small-fruited False-flax. Hillsboro, Highland Co. Katie M. Roads.

690. *Neslia paniculata* (L.) Desv. Ball-mustard. Barnesville, Belmont Co. Emma E. Laughlin.

703. *Thlaspi arvense* L. Field Penny-cress. Barnesville, Belmont Co. Emma E. Laughlin.

708. *Cheirinia cheiranthoides* (L.) Link. Worm-seed Mustard. St. John's woods, Bowling Green, Wood Co. E. L. Moseley.

754. *Polanisia graveolens* Raf. Clammy-weed. Near Hillsboro, Highland Co. Katie M. Roads.

764. *Erodium cicutarium* (L.) L'Her. Hemlock Stork's-bill. Glen Mary, Franklin Co. Howard W. Johnson.

774.1. *Linum striatum* Walt. Ridged Flax. "In orchard" near Barnesville, Belmont Co. Emma E. Laughlin.

776. *Linum medium* (Planch.) Britt. Stiff Flax. Washington Twp., Highland Co. Katie M. Roads.

804. *Tithymalus peplus* (L.) Hill. Petty Spurge. "Persistent weed in an old garden." Somerton, Belmont Co. Emma E. Laughlin.

848. *Hypericum drummondii* (Grev. & Hook.) T. & G. Drummond's St. John's-wort. North of Lore City, Guernsey Co. Emma E. Laughlin.

849. *Sarothra gentianoides* L. Orange-grass. Union Twp., Scioto Co. John H. Schaffner.

875.1. *Viola cucullata* Ait. Marsh Blue Violet. Collected by Otto Hacker at Painesville, Lake County, in 1902. Determined by R. Crane.

892. *Moehringia lateriflora* (L.) Fenzl. Bluntleaf Moehringia. Liberty Twp., Wood Co. E. L. Moseley.

923. *Vacaria vacaria* (L.) Britt. Cowherb. "Along a railway track," near Hillsboro, Highland Co. Katie M. Roads.

925. *Dianthus armeria* L. Deptford Pink. Buchtel, Athens Co. Len. Stephenson. Also along Pond Lick Road, Scioto Co. Arthur R. Harper.

1016. *Drymocallis agrimonioides* (Pursh) Rydb. Mac-o-cheek Castle, Logan Co. Arthur R. Harper.

1017. *Waldsteinia fragarioides* (Mx.) Tratt. Dry Strawberry. "On the top edges of cliffs at Rocky Fork Caves." Paint Twp., Highland Co. Katie M. Roads.

1037. *Spiraea tomentosa* L. Steeple-bush. Oxford Twp., Erie Co. E. L. Moseley.

1116. *Trifolium arvense* L. Rabbit-foot Clover. Fairview, Guernsey Co. Mrs. T. S. Rosengrant. Also Guernsey Co. Fair Ground. Emma E. Laughlin. Also Gallipolis, Gallia Co. Arthur R. Harper.

1135. *Stylosanthes biflora* (L.) B. S. P. Pencil-flower. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1151. *Lespedeza repens* (L.) Bart. Creeping Bush-clover. "In a virgin forest" S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

1160.1. *Lespedeza striata* (Thunb.) H. and A. Japan Bush-clover. In a meadow locally called "Buffalo Beat,"

Buchtel, Athens Co. "The Lespedeza forms a thick mat." Collected by Len Stephenson. Received from Freda Detmers, Ohio Agr. Exp. Sta., Wooster. Also near Portsmouth, Scioto Co. John H. Schaffner and C. K. Kao.

1161.1. *Vicia villosa* Roth. Hairy Vetch. Procterville, Lawrence Co. R. B. Gordon.

1181. *Sedum triphyllum* (Haw.) S. F. Gr. Live-forever. Lake Twp., Ashland Co. Also near Warren, Trumbull Co. John H. Schaffner.

1200. *Rhexia virginica* L. Virginia Meadow-beauty. Rarden, Scioto Co. Also present at Blue Creek, Adams Co. Conrad Roth.

1207. *Ceanothus americanus* L. Common New Jersey Tea. Washington Twp., Highland Co. Katie M. Roads.

1372. *Lysimachia quadrifolia* L. Whorled Yellow Loosestrife. Marshall Twp., Highland Co. Katie M. Roads.

1380a. *Anagallis arvensis coerulea* (Schreb.) Ledeb. Blue Pimpernel. "Edge of a waste lot," Hillsboro, Highland Co. Katie M. Roads.

1389. *Chimaphila maculata* (L.) Pursh. Spotted Pipsissewa. Washington Twp., Highland Co. Katie M. Roads.

1396. *Azalea viscosa* L. Swamp Azalea. Eliminate from the list. Alfred Rehder of Arnold Arboretum found that our specimen was incorrectly determined.

1420. *Phlox pilosa* L. Downy Phlox. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1433.1. *Convolvulus repens* L. Trailing Bindweed. On "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1434. *Convolvulus japonicus* Thunb. Japanese Bindweed. "A large and well-established area along the B. & O. S. W. railway to the north and west of Hillsboro," Liberty Twp., Highland Co. Katie M. Roads.

1448. *Hydrophyllum canadense* L. Broadleaf Water-leaf. Near Hillsboro, Highland Co. Katie M. Roads.

1469. *Gentiana flavida* Gr. Yellowish Gentian. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1481.1. *Asclepiodora viridis* (Walt.) Gr. Oblong-leaf Green Milkweed. "Limestone ravine," near Rarden, Adams Co. Arthur R. Harper.

1501.1. *Browallia demissa* L. Browallia. "Persistent after cultivation." Hillsboro, Highland Co. Katie M. Roads.

1504. *Physalis ixocarpa* Brot. Mexican Ground-cherry. "Three large plants growing along railroad switch." Barnesville, Belmont Co. Emma E. Laughlin.

1555. *Aureolaria flava* (L.) Farw. (Dasystoma virginica (L.) Britt.) Smooth False Foxglove. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson. Also "in a virgin forest" S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

1568. *Chaenorrhinum minus* (L.) Lange. Lesser Toadflax. "Very common along railway tracks" near Hillsboro, Liberty Twp., Highland Co. Katie M. Roads.

1570. *Kickxia elatine* (L.) Dum. Sharp-pointed Toadflax. St. Paris, Champaign Co. Ruth Rider.

1586. *Ruellia strepens* L. Smooth Ruellia. Buchtel, Athens Co. Len. Stephenson.

1600. *Lithospermum officinale* L. Common Gromwell. Cincinnati, Hamilton Co. O. T. Wilson.

1616. *Trichostema dichotomum* L. Blue-curls. Buchtel, Athens Co. Len. Stephenson.

1627. *Scutellaria integrifolia* L. Hyssop Skullcap. Procterville, Lawrence Co. R. B. Gordon.

1665.1. *Moldavica parviflora* (Nutt.) Britt. American Dragonhead. "On a vacant lot." Barnesville, Belmont Co. Emma E. Laughlin.

1701. *Aralia hispida* Vent. Bristly Sarsaparilla. Thompson's Ledge, Geauga Co. Arthur R. Harper.

1704. *Eryngium aquaticum* L. Rattlesnake-master. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1713.1. *Anethum graveolens* L. Dill. "In a waste lot." "Persistent after cultivation." Hillsboro, Highland Co. Katie M. Roads.

1753.1. *Houstonia lanceolata* (Poir.) Britt. Calycose Houstonia. "In a wood." Washington Twp., Highland Co. Katie M. Roads.

1760. *Diodia teres* Walt. Rough Buttonweed. Buchtel, Athens Co. Len. Stephenson.

1760.1. *Galium vernum* L. Yellow Bedstraw. "Clay bank on the National Road, about four miles east of Cambridge," Guernsey Co. Emma E. Laughlin.

1764. *Galium boreale* L. Northern Bedstraw. Margaretta Ridge, Erie Co. H. C. Schoepfle. Presented by E. L. Moseley.

1802. *Diervilla diervilla* (L.) MacM. Bush-honeysuckle. Thompson's Ledge, Geauga Co. Arthur R. Harper.

1819. *Lobelia leptostachys* A. DC. Spiked Lobelia. "Banks of a small stream." Marshall Twp., Highland Co. Katie M. Roads. Also "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1830. *Heliopsis scabra* Dunal. Rough Oxeye. Hillsboro, Highland Co. Katie M. Roads.

1834. *Rudbeckia fulgida* Ait. Orange Cone-flower. Near Captina Creek, about eight miles S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

1835. *Rudbeckia speciosa* Wend. Showy cone-flower. Jefferson Twp., Adams Co. John H. Schaffner.

1839. *Echinacea purpurea* (L.) Moench. Purple Cone-flower. "Edge of a dry rocky wood." Washington Twp., Highland Co. Katie M. Roads. Also "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1857. *Phaethusa helianthoides* (Mx.) Britt. Sunflower Crownbeard. "Frequent along roadsides," Scioto Co. Arthur R. Harper.

1886. *Helenium nudiflorum* Nutt. Purple-headed Sneezeweed. Dundas, Vinton Co. Arthur R. Harper.

1909. *Solidago erecta* Pursh. Slender Goldenrod. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1912.1. *Solidago odora* Ait. Sweet Goldenrod. Roosevelt Forest Preserve, Scioto Co. Conrad Roth.

1922. *Solidago rigida* L. Stiff Goldenrod. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1930. *Siricocarpus asteroides* (L.) B. S. P. Toothed Whitetop Aster. "Buffalo Beat," near Buchtel, Athens Co. Len Stephenson.

1934. *Aster azureus* Lindl. Azure Aster. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1942. *Aster phlogifolius* Muhl. Thinleaf Purple Aster. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1947.1. *Aster concinnus* Willd. Narrowleaf Smooth Aster. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1967. *Ionactis linariifolius* (L.) Greene. Stiffleaf Aster. McDermott, Scioto County. Conrad Roth.

1978. *Kuhnia eupatorioides* L. False Boneset. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1980. *Lacinaria cylindrica* (Mx.) Ktz. Cylindric Blazing-star. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

1982. *Lacinaria scariosa* (L.) Hill. Large Blazing-star. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson. Also in Union Twp., Scioto Co. and Jefferson Twp., Adams Co. John H. Schaffner.

1988. *Elephantopus carolinianus* Willd. Carolina Elephant's-foot. Buchtel, Athens Co. Len. Stephenson.

1999. *Matricaria matricarioides* (Lees.) Port. Rayless Camomile. Barnesville, Belmont Co. Emma E. Laughlin.

2014. *Senecio pauperculus* Mx. Balsam Squaw-weed. Put-in-Bay, Ottawa Co. E. L. Moseley.

2026a. *Cirsium arvense integrifolium* Wimm. & Grah. North of Akron, Summit Co. C. J. Willard.

2029.2. *Centaurea nigra* L. Black Star-thistle. "Pasture-field" south of Barnesville, Belmont Co. Emma E. Laughlin.

2030.1. *Centauria solstitialis* L. Barnaby's Star-thistle. "In alfalfa field." Celina, Mercer Co., collected by Banks Collings. Specimens also sent to the Ohio Agr. Exp. Sta. at Wooster, from Fulton, Van Wert, and Ross counties. "From alfalfa fields, the plant probably being introduced with the alfalfa seed." Freda Detmers. Also Greenville, Darke Co. R. C. Smith.

2039. *Sonchus arvensis* L. Field Sow-thistle. Barnesville, Belmont Co. Emma E. Laughlin.

2043.1. *Lactuca sativa* L. Garden Lettuce. "Along railway track," near Hillsboro, Highland Co. Katie M. Roads.

2047. *Lactuca villosa* Jacq. Hairy-veined Blue Lettuce. "Buffalo Beat," near Buchtel, Athens Co. Len. Stephenson.

2051.1. *Nabalus serpentarius* (Pursh) Hook. Lion's-foot (Rattlesnake-root). Buchtel, Athens Co. Len. Stephenson.

2054. *Nabalus crepidineus* (Mx.) DC. Corymbed Rattlesnake-root. Eight miles S. E. of Barnesville, Belmont Co. Emma E. Laughlin.

2064.1. *Crepis biennis* L. Rough Hawksbeard. Buchtel, Athens Co. Len. Stephenson.

THE NATURAL VEGETATION OF OHIO.

PAUL BIGELOW SEARS
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I. A Map of the Virgin Forest.

SOURCES UPON WHICH THE MAP IS BASED.

This map has been prepared by transcribing the species of bearing trees recorded by the original surveyors who traversed the Territory and State of Ohio before the destruction of the virgin forest by the hands of white men.

Surveying of Ohio was begun in July, 1786, (1) under The Geographer of the United States, Thomas Hutchins, employing for the first time his device of sections one mile square. This empirical device was hailed as a great American invention, although the State of Ohio has since been found to possess a curved surface in common with the rest of the earth. All corners which lay within the forest were located with reference to nearby trees, the species of which were noted. These corners becoming permanent, the net result of Hutchin's plan has been the preservation of a systematic record of such great biological value as to redeem its geometrical shortcomings.

Following the death of Hutchins, active surveying seems to have gone slowly until about 1796. The parcels into which the region was divided are shown in the sketch map, Fig. 1. The Virginia Military Bounty was never surveyed systematically, nor have records for the lower portion of the Symmes Purchase been at hand in usable form. Within the United States Military Bounty most townships were surveyed in part only. The portion of the Western Reserve between the Cuyahoga River and the west line of Lorain County was merely reconnoitered at the time of the first survey. The remainder of the Western Reserve, all of the Congress Lands, and the Seven Ranges were surveyed throughout, traverses in the Reserve being limited to township, rather than section lines as elsewhere. The records of the Western Reserve are still in manuscript form in the vaults of the Western Reserve Historical Society at Cleveland. They

form a document of great interest—sufficient, in fact, to have warranted the special publication of that part dealing with the "Firelands" (now Erie and Huron Counties) by the Firelands Pioneer of Norwalk. Records for the Ohio Company's Pur-

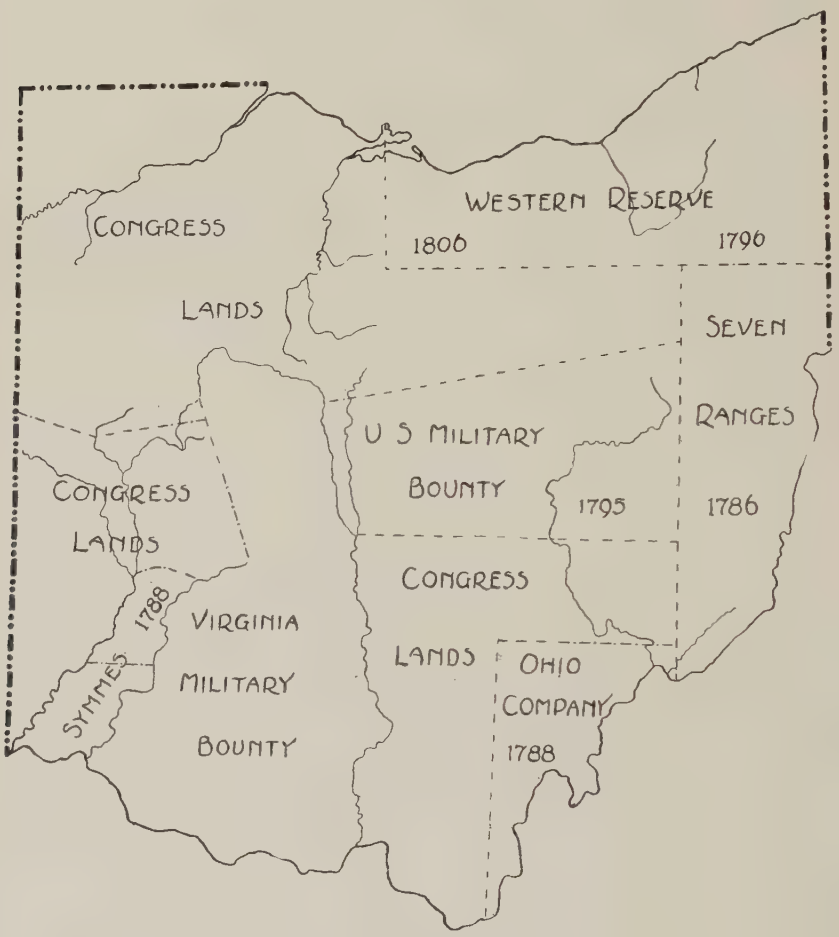

Fig. 1. Ohio Land Parcels.

chase are at Marietta. The remaining field notes are in the office of the Auditor of State at Columbus. Portions dealing with a given county are often copied and the copy filed in the county engineer's office.

For those districts whose record is lacking or incomplete, it has fortunately been possible to secure considerable information

from county histories, the earlier volumes of the geological survey, journals of travelers, verbal descriptions and other historical sources. Throughout all of the state except the southern and eastern portions the writer has frequently had opportunities to check the historical record against the present field conditions. The technique employed in transcribing and interpreting data has been described earlier, (2).

The writer is indebted to the Trustees of the Emerson McMillan Research Fund of the Ohio Academy of Science, and to Chancellor Samuel Avery, of the University of Nebraska for financial assistance in meeting the expenses of field work. For escape from many errors of judgment he must thank his former colleagues in botany at Ohio State University. Mrs. Marjorie McCutcheon Sears and Miss Helen Nott have helped greatly in transcription, the latter securing data on the Ohio Company's Purchase made available through the courtesy of the librarian of Marietta College.

Many other individuals have been of more than casual service—Captain Henry, of the State Auditor's Office, and Curator Cathcart, of Cleveland, to mention two. Moreover, the ready encouragement of Professor Henry C. Cowles has been invaluable.

HOW TO READ THE MAP.

Townships have been selected as convenient units for this map. Some are five, some six miles square, but in any case an effort has been made to generalize the forest type within each township. With few exceptions most townships have been classified as fundamentally "Beech," "Oak," or "Ash"—or various combinations of these types. The sense in which these three terms are employed must be clearly understood. The data at hand are involved, and it is only by being somewhat arbitrary that one can bring them all to rest peaceably upon a map of the present scale. (Fig. 2).

Beech, represented by a vertical cross, or plus mark, in most cases consisted of beech and sugar maple. Upon certain old upland flats and thin-soiled patches known as "scalded" or "thin" beech land, the sugar was absent. In typical beech-sugar maple a sprinkling of white ash and red oak was the rule. Unless their numbers were very large, however, no signs for oak and ash have been added in such cases.

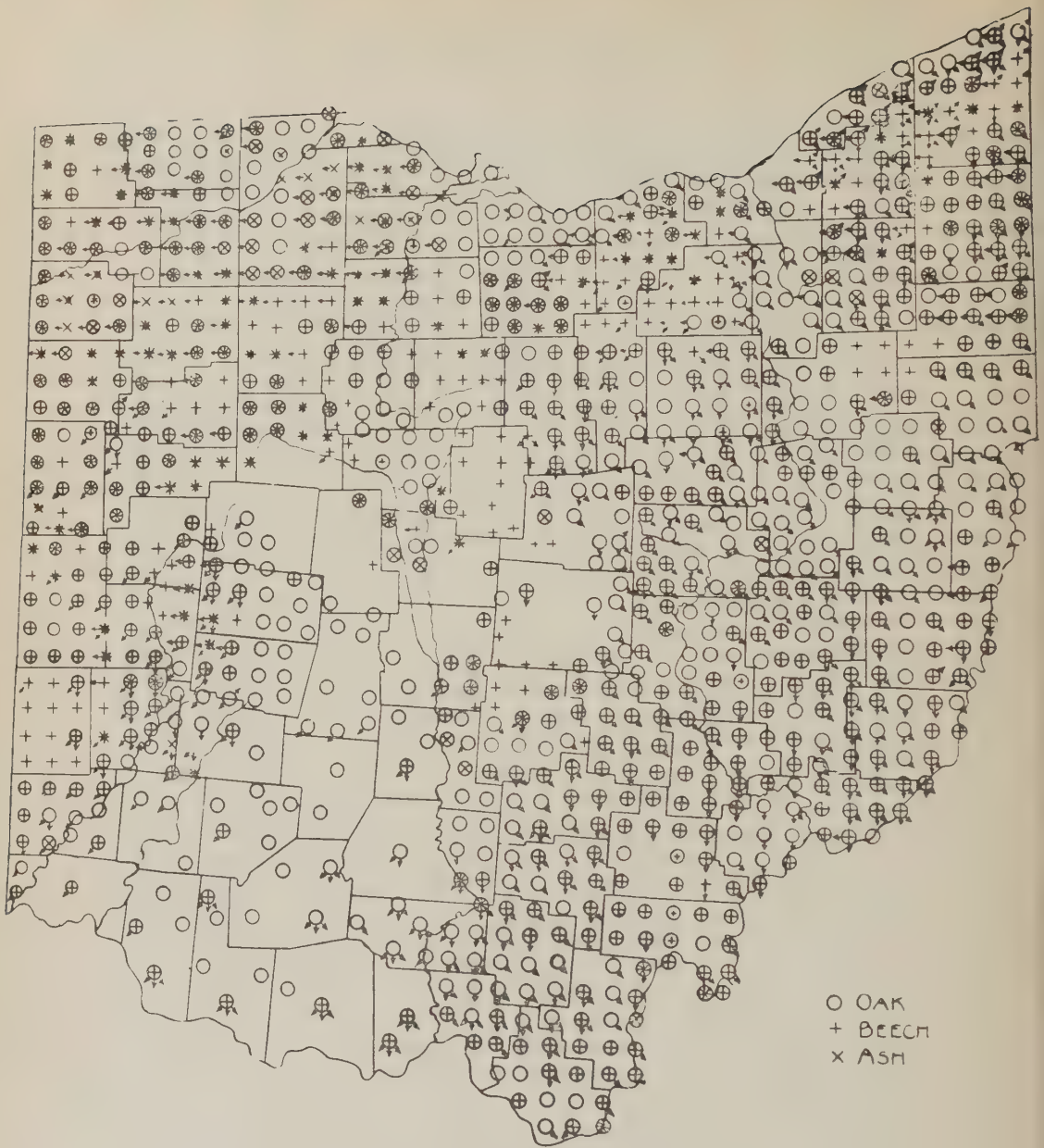

Fig. 2. Map of the Ohio Virgin Forest.

"Beech" designates pure stands of beech, also beech-maple with (often) more or less red oak and white ash.

"Oak" includes white oak, hickory, burr oak, black oak; also chestnut-chestnut oak.

"Ash" designates black ash—white ask, usually with elm, and often with red maple.

Arrows point toward the approximate present-day centers of distribution of species additional to the above. See text for further explanation of symbols.

Oak is represented by a circle. The most frequent grouping of oaks throughout the state was white oak, black oak, and hickory; with chestnut oak when chestnut was present; with burr oak (often scrubby) in many prairie habitats; with red oak in mixtures containing sugar maple and beech; and with other oaks chiefly in rather restricted conditions. At places, e. g. the lower Scioto valley, in mixtures with poplar, cherry, walnut, etc. "Oak" was mainly represented by hickory. This was unusual. The oak type, then, was primarily white oak—black oak—hickory with the qualifications above listed.

Ash is indicated by an X. Theoretically we should expect white ash to have been limited to the mesophytic beech-sugar maple association. Black ash on the other hand would be looked for principally in the colder and more youthful swamp forests. Actually, however, when much ash was present, black and white ash seem to have been so intermingled, along with elm and frequently soft maple, that the symbol for ash really indicates these four trees, in varying proportions.

Besides the trees designated by Oak, Ash, and Beech, other trees were found in significant numbers in many townships. To indicate these associated species arrows have been used upon the map.

Arrows pointing northeast indicate the presence of hemlock, white pine, or (as in southern Clarke County) arbor vitae. Some of the birches and alders found in Ohio ought to be included in this group, but unfortunately we cannot gather from the record whether northerly or southerly species were meant in any given case.

Arrows pointing southeast symbolize the following, easterly or southeasterly: chestnut, chestnut oak, scrub pine, and pitch pine.

Arrows pointing southward indicate one or more of these species: black cherry, cucumber magnolia, both gums (sweet gum or liquidamber and tupelo, pepperidge, sour or black gum—the latter being much more common), and tulip poplar.

Arrows pointing southwest indicate the presence of any of the following, to wit: buckeye (sweet and Ohio), dogwood, hackberry, sycamore, and black walnut. Of these the Ohio buckeye, sycamore and black walnut are perhaps more strictly southern than southwestern with respect to Ohio. Inasmuch, however, as all form a more or less coherent group whose center

of dispersal in Ohio is without question the southwestern corner of the state, the liberty taken is believed to be justified. (3).

Arrows pointing westward signify linden, ironwood, or cottonwood.

Treeless areas are not indicated upon the map, nor, generally, are such local details as restricted swamps. There were, for example, small stands of tamarack in Portage, Williams, and Defiance Counties which are not shown.

DISTRIBUTION OF THE CONSPICUOUS FOREST TREES.

Looking over the map as a whole it will be noted that Oak was the most ubiquitous type, with Beech second, and Ash distinctly third. All were found mixed more often than alone. The arrows pointing toward the range centers of associated species show a grouping, on the whole, such as one would normally expect.

The primary physiographic divisions of the state (4) are the Erie Plain and Alleghany Plateau. Glaciation, however, extended well beyond the plain into the plateau. The present drainage basin of Lake Erie does not coincide with the Erie Plain exactly, falling a little north of it at the West, and considerably south of it toward the East. A further important boundary seems to be that between the Carboniferous and Devonian, roughly making a vertical bisect of the state, turning east along the lake and a short distance west along the Ohio River. To the right of this line are mainly sandstones and shales, with some limestone, to the left of it mainly limestone and shales.

Summarizing, then, we get (Fig. 3):

AA—Erie Plain-Alleghany Plateau.
BB—Erie-Ohio Divide or Crestline.
CC—Carboniferous-Devonian Boundary.
DD—Glacial Boundary.

Certain facts with regard to the associated species (those indicated by arrows upon the map, Fig. 2) now become of interest.

Species from the West—ironwood, linden, cottonwood—were most common in the northwestern part of the state, within the Erie Plain, which here forms a broad shallow pass across Indiana and into the Mississippi Valley.

Southwestern species as we have here called them (buckeye, black walnut, hackberry, sycamore) were most numerous upon the glaciated Ohio Basin-Alleghany Plateau at the southwestern corner of the state. From that point they diverged eastward

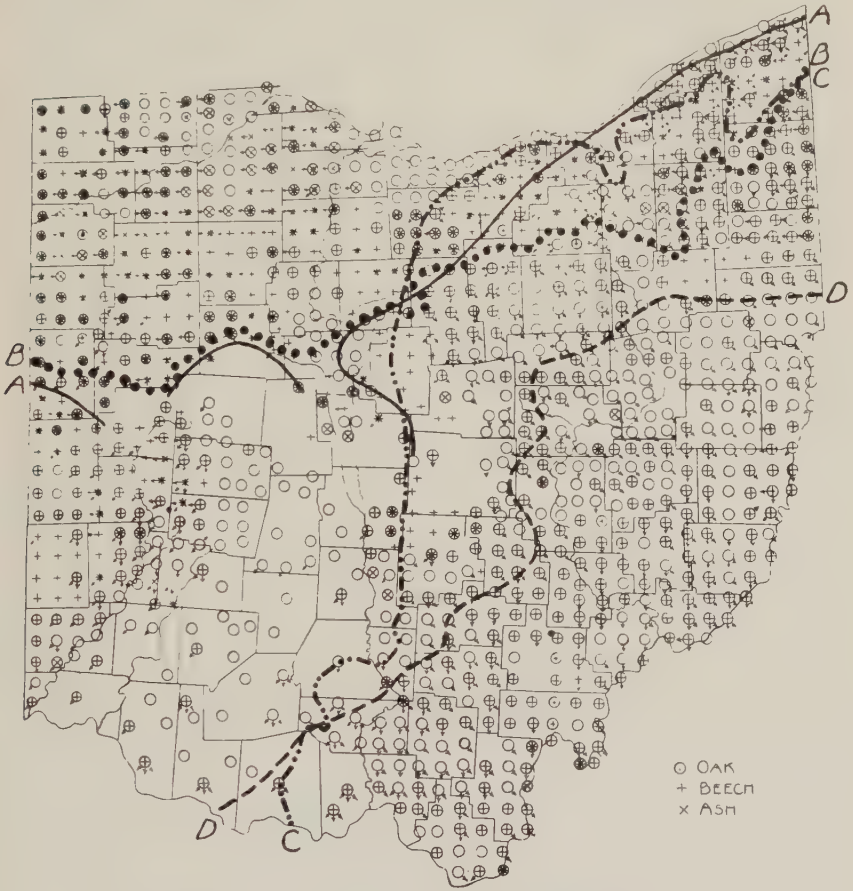

Fig. 3. Ohio Physiographic Boundaries.

A-A, Erie Plain-Alleghany Plateau; C-C, Carboniferous-Devonian Line;
B-B, Lake Erie-Ohio River Divide; D-D, Glacial Limit.

and northward along the Upper Ohio and its great tributaries, the two Miamis and the Scioto. Obviously, at the southwestern corner of the state the Ohio Valley itself forms a pass southwestward toward the lower Mississippi region.

Southeastern and southern forms—chestnut, chestnut oak, pitch pine, scrub pine, and cucumber, tulip, gums, cherry—were all found principally east of the Devonian boundary upon Carboniferous substratum and were upon the whole decidedly more conspicuous upon the unglaciated area than elsewhere. There were indeed groves of chestnut in Wood and Butler counties, (Fig. 4), but upon sandy soil in both instances. It scarcely needs to be pointed out that the unglaciated Alleghany Plateau, extending as it does without interruption on into the southern and southeastern Appalachians, constitutes a pass in the sense of a continuity of habitat.

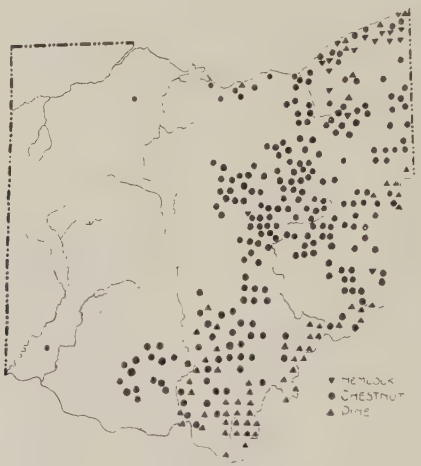

Fig. 4. Records of Hemlock, Chestnut and Pine in the Virgin Forest of Ohio.

Hemlock and white pine from the northeast were most abundant in the patch of glaciated Devonian at the northeast corner of the state (Fig. 4), but were found to some extent throughout the eastern half of the glaciated plateau lying north of the present Erie-Ohio Divide. They seem to have occupied rather deep and sheltered north-facing ravines which open out onto the lake. The arbor vitae swamp in southern Clarke County was an isolated outlier, comparable with the hemlock in Knox and Belmont counties.

Species from all directions—even a few from the southwest which had farthest to come—met and overlapped in a great focus or complex near the northeastern corner of Ohio. A

glance at the map, Fig. 3, shows clearly that here the physiographic boundaries approach most closely. It does not seem difficult to explain why the native forest here developed its greatest diversity.

Turning now from the various groups of associated species to the three characteristic groups, we note that:

Oak unmixed with Beech or Ash was found upon both glaciated and unglaciated areas;

Beech unmixed with Oak or Ash was practically limited to the glaciated region, while the unmixed Ash was still more restricted, being largely within the Erie Plain.

It will be recalled that the unglaciated area is a region of strong relief. Oak here occupied the exposed hilltops, with chestnut, chestnut oak, or pine. Beech was interspersed with southern mesophytes throughout the denser upland forests and in ravines. The virgin forest of the unglaciated region was not a homogeneous mixture, however, as Figs. 4 and 5 clearly show. The same conclusion has been reached by Schaffner (5) and Transeau (unpublished) working on different lines of evidence.

With respect to the glaciated region, certain broad general principles of distribution are recorded in Fig. 5. Here are shown the moraine system after Leverett (6) and the position of Beech and Oak. Mixtures of Beech and Oak have been omitted for the sake of clarity, as has Ash.

A comparison of Figs 3 and 5 makes it clear that Ash was most abundant upon certain broad intermorainal flats or depressions—i. e. of the ground moraine. This was especially true for the Erie Lobe (Black Swamp Region), although both the Scioto and Grand River Lobes show Ash similarly located.

Beech, it will be noted from Fig 5, was on the whole most abundant along the edges of the great glacial lobes. That is to say it occupied, if not always actual lateral moraines, at least the lateral regions of the ground and terminal moraines.

Oak, on the other hand, was found chiefly near the apex of each glacial arc, in that region where ground and terminal moraines intermingle. Such regions afford characteristic knob and kettle topography. The position of oak here was usually closely associated with swamp or wet prairie. It is important to remember, however, that oak did not occur in the actual depressions themselves. It grew upon the knobs which were elevated, often slightly, above the adjacent glacial puddles.

Oak was also found upon old beach dunes in Fulton and Lucas counties, upon limestone ridges near Sandusky Bay, eastward upon high exposed clay cliffs above Lake Erie, and elsewhere upon the tops of very high, exposed, although glaciated hills.

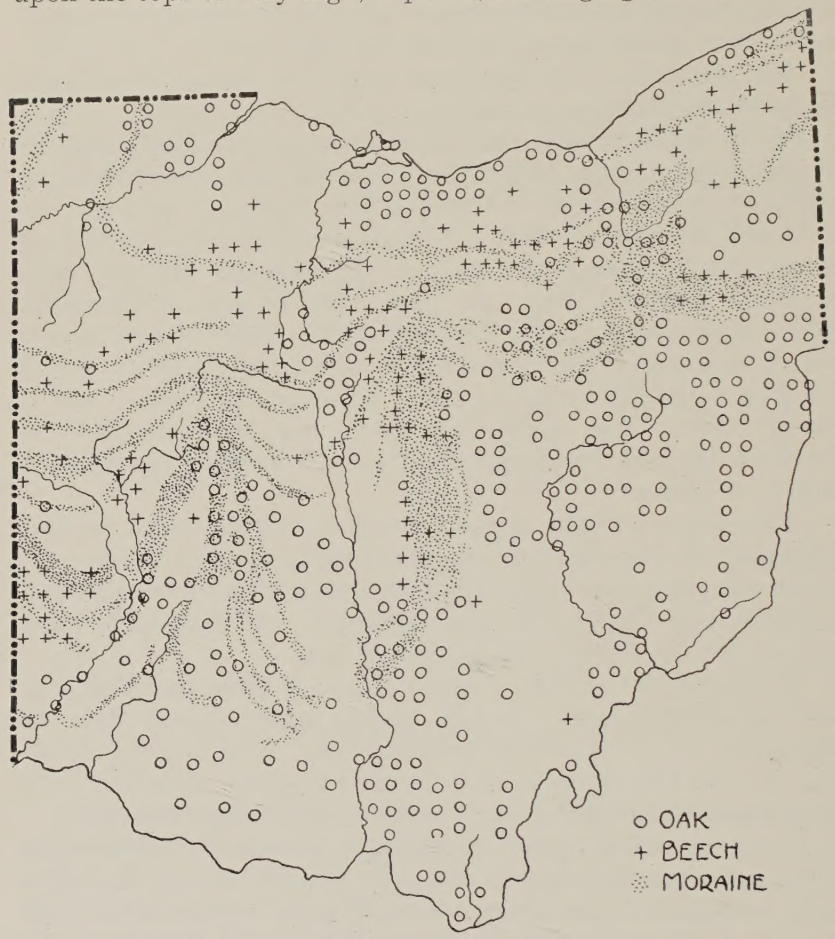

Fig. 5. Native Oak and Beech Forest in Relation to the Moraine System of Ohio.

SUMMARY AND CONCLUSIONS.

Deferring for the present the matter of plant succession we have the following general facts about the Ohio virgin forest.

1. The most characteristic species groups within the state were, first, Oak, (black oak—white oak—hickory, etc.); second,

Beech (beech—sugar maple, etc.); third, Ash (black ash—white ash—elm—maple, etc.). These groups were intermingled more often than not. Unmixed Beech was practically limited to the glaciated region. Ash was best developed within the Erie Plain.

2. The distribution of these characteristic species groups within the glaciated area was primarily correlated with the moraine system. Broadly speaking, Beech tended to appear along the sides, Ash upon the central ground, and Oak towards the central terminal region of the glacial lobes.

3. With these groups of species were associated others whose range centers lay outside of Ohio. By far the most widespread of these groups was the generally southerly one, comprising the Southeastern (chestnut, pine, etc.), Southern (cherry, gums, tulip, etc.), and Southwestern (buckeye, hackberry, etc.). A Western group (linden, cottonwood, etc.) was somewhat less extensive, while northerly groups—Northern (tamarack) and Northeastern (hemlock, white pine, etc.) were decidedly restricted.

3. The distribution of these associated species was correlated broadly with the fundamental physiographic boundaries within Ohio, i. e., Plateau-Plain, Crestline, Glacial Limit, and Carboniferous Escarpment.

4. The facts of distribution of species groups in the unglaciated area accord substantially with the recent, as yet unpublished, field studies of Transeau. He has correlated these facts with the surface geology.

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Date of Publication, May 19, 1925.